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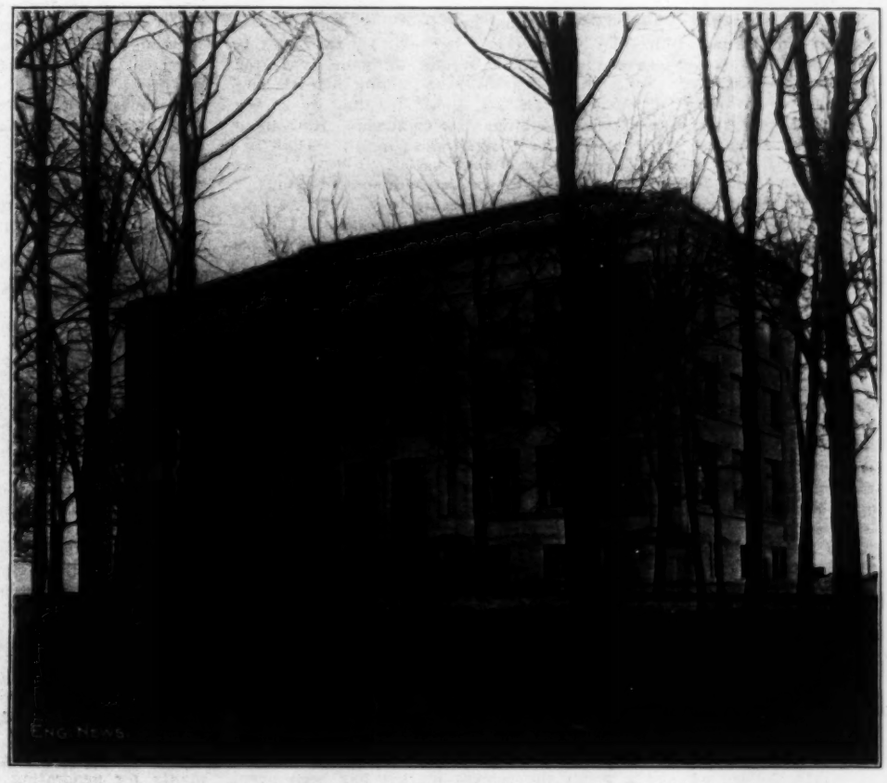
Dedication of the Swift Engineering Building at Northwestern University.

A college of engineering has been established at Northwestern University, Evanston, Ill., and a new building has been erected for its use. This building was formally dedicated on Friday, May 7, in the presence of the University Trustees and Faculty, the student body, engineers resident in Chicago and vicinity and representatives of other Western Universities.

The dedication exercises included addresses by the President of the University, Dr. A. W. Harris, by the Director-Elect of the new engineering college, Mr. John F. Hayford, of the U. S. Coast & Geodetic Survey, and by Mr. Charles Whiting Baker, Editor of Engineering News. Following these came the presentation of the keys on behalf of the donors of the building, and a luncheon.

The new building occupies a fine site on the Lake front. Its exterior is of light gray Indiana limestone. The building is of fireproof construction with floors of reinforced concrete, and concrete finish is used throughout with woodwork of dark oak. A photograph of the building is reproduced herewith.



SWIFT HALL OF ENGINEERING, NORTHWESTERN UNIVERSITY, EVANSTON, ILL.

We print below the addresses of Mr. Hayford and Mr. Baker slightly condensed.

The New College of Engineering, an Opportunity.

By JOHN F. HAYFORD,* M. Am. Soc. C. E.

A great opportunity is before us. Through the generosity of Mrs. G. F. Swift and Mr. Edward F. Swift an excellent building for the new College of Engineering has been erected and its maintenance provided for. The Board of Trustees has determined to furnish the necessary funds to develop the new college.

In order to utilize well this great opportunity it is important that we should have a reasonably well-defined ideal toward which to strive. To work without an ideal is to invite disaster from the changing currents of general tendencies and of personal opinions, and the strong deep currents of prejudice.

We might take it as our task to convert the high school graduates who come to us as freshmen into men who will leave these grounds five or six years later as engineers fully trained and completely equipped mentally for their life work. This ideal cannot be even approximately attained.

Instead, our ideal should be so to train these young men in college that they will be capable of becoming engineers, and will have a tendency to become great engineers. We may hope to make a reasonably close approach to this ideal. We may hope to lay such a foundation of motives, of methods of thought, of principles which have been mastered, and of acquired information that our graduates may, with accumulated experience and strength acquired by effort, become good engineers ten years after commencement, and in the unusual cases become great engineers within twenty years of service.

As our purpose is to equip the graduate for unlimited growth as an engineer, rather than for the greatest immediate usefulness, it is obvious that we should put the emphasis in our teaching strongly upon the fundamentals, upon mathematics, chemistry, physics and mechanics.

In teaching the broad principles which underlie engineering, the college has great advantages over the school of experience. On the other hand, skill, special knowledge and that familiarity with details which is a part, but not all, of experience, may clearly be best obtained outside the college, in the practice of engineering. These considerations indicate approximately how to make the difficult decisions as to the amount of shop work, laboratory work, and drafting which should be put into our curriculum. These courses serve in part one purpose, to illustrate principles, to make them concrete and thereby both to strengthen the grasp of the student upon the principles and to increase his interest in them. These courses, especially if made extensive, also serve another purpose, namely, to develop some skill and judgment in the manipulation of instruments, tools and apparatus. In accordance with our ideal, we should endeavor to stop when the first purpose has been accomplished. To endeavor to accomplish the second purpose also by more shop work, laboratory work and drafting during the college years will necessarily crowd out other courses in lines in which teaching may be done much more effectively in college than out of it.

The student should, however, be encouraged to engage in practical work connected with engineering, during his summer vacations. He may gain from this, in somewhat the same manner as from his first experiences after graduation.

In the statement of our ideal we have ac-

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knowledged that the embryo engineer has much to learn after he leaves college and before he becomes a full-fledged engineer. It follows, therefore, that it will be a mistake to keep him too long in college, just as truly as it will be a mistake to turn him out too soon, with too little training. With each year added to his life, the man tends to become less quick to learn new ways, less keen to profit by new experiences. We should not delay unnecessarily the date on which our graduate begins his work in the world. While he is in college he is surrounded by men who are endeavoring to teach him. He has put before him organized knowledge, carefully arranged and carefully presented. As soon as he steps out of college, or at least as soon as he rises above the lowest rank in his profession, the knowledge which it is most important for him to acquire is that which lies outside the field of well-organized knowledge. It comes to him in chaotic fashion. His fellow workers and his official superiors have but little interest in helping him to learn, and still less activity in that line. With each additional year the young man stays in college, it becomes more difficult for him to adjust himself to this radical change in conditions when he goes out.

We should avoid sending out our graduates handicapped by ignorance of men. Cases are not infrequent in the engineering world in which the upward progress of an engineer is absolutely stopped by his clumsiness in dealing with men, even though he has great skill in dealing with materials and forces. It is our duty to teach our future engineers not only about forces and materials but that their future success in utilizing their engineering knowledge and skill depends upon their ability to work with men, and through men.

In the College of Engineering we may expect certain difficult problems to be ever present. The success of the college depends largely upon our success in solving these problems. I suggest three examples.

Language is one of the important tools of an engineer. He must have the power to convince. He must have the ability to use English accurately and effectively or be handicapped even in his strictly engineering work. One who acquires the ability to speak and write accurately and well, usually acquires with it the power to think accurately. How can we best help the student in his college days to acquire the ability to speak and write?

It is a comparatively easy matter to lead a student along a given line of thought, but how can the student be trained to think for himself?

We should aim, in the College of Engineering, to give our students a broad training, yet we desire to give them thorough training along certain lines. How is the broadening to be secured? Is it to be gained from certain courses intended for that especial purpose, or is it to be secured by the manner of teaching each course, even technical courses.

The real success of the College of Engineering is dependent upon the solution of ever present problems of which these are but examples. Because of the existence of numerous problems of this character which are common to the whole University, the College of Engineering gains strength from being a part of Northwestern University, rather than a separate institution.

Let us adopt as the motto of the College of Engineering "Culture for Usefulness." Let us put the emphasis strongly on the last two words. The attempt merely to obtain culture may be self-centered. The attempt to gain culture for the purpose of increasing one's usefulness in the world is essentially unselfish. In setting this motto before our students and in thus suggesting that they are to seek culture, not primarily for themselves but in order to increase their usefulness in the world, usefulness of the broadest kind in the great united struggle of man for progress, we shall be setting before them an ideal which includes all others.

We are here to-day to dedicate a building to engineering education. In a deeper and better sense, we are here to dedicate ourselves to the highest and best use of the great opportunity which the building represents, an opportunity to give an uplift to the ideals and to increase the usefulness of thousands of young men who are to enter their life work through that building, an opportunity to help in raising the standard of engineering education, an opportunity to help in making American Universities of the greatest real service to American people.

A Broader Training for the Engineer.

By CHARLES WHITING BAKER, M. Am. Soc. M. E.

The beautiful new building which you to-day dedicate calls to my mind in contrast a plain old building at my own Alma Mater, in which my college work was done. The four walls of that building were as barren of architectural adornment as the cotton mills in the near-by village, and so the building had been known to many generations of students as "The Mill."

Realizing the associations which cluster in my mind around that old building, you will understand that I intend no disrespect if I liken your beautiful new building to a mill. A new mill added to a large and prosperous manufacturing plant. A new mill to turn out a new product.

A new product, did I say? No, not a new product, but a staple article. There was a time, it is true, within the memory of men still young, when the engineering graduate was a novelty in the market—a novelty which sometimes found eager purchasers but which at other times literally went begging.

That era long ago passed away. Training men for the engineering profession in college is no longer an experiment. The engineering graduate is a staple product.

But even staple products are sometimes a drug in the market. No man builds a mill to produce even such staples as flour or cotton cloth, without carefully examining market conditions. It is fitting, therefore, that we survey the market conditions for engineers. How stand the relations of demand and supply? What sort of engineers are most needed to-day? What grade of flour will you set your mill to grind?

Perhaps I can best picture to you market conditions in the engineering profession if I draw a parallel between the engineer and one of his favorite materials—Portland cement.

A quarter of a century ago, Portland cement was an expensive and little-used article—just like the engineer of a somewhat earlier period. The valuable qualities and many uses of Portland cement were little appreciated when it was first introduced. The pioneer engineers suffered in like manner. To-day fifty huge mills are producing Portland cement where there was one a generation ago. So where there were four small struggling schools of engineering in the United States in 1850, there are to-day more than fifty times that number, and many of these schools number their students by hundreds and even by thousands.

Manifestly these huge mills for making Portland cement would not have been erected if the public had not found a use for their product. So also the engineering schools could not have multiplied in number and grown in size as they have done if the public had not found the engineering graduate a useful and valuable member of society. But I am bound to say to you that enterprise in the erection of Portland cement mills has at times outstripped demand, and as a result the cement market has been overstocked. The market for engineers follows quite closely the market for cement, and during the past two years there have been many idle cement mills and idle engineers.

With both the cement mills and the engineers it has been a case of competition, and survival—if not of the fittest, then of those best able to survive. Undoubtedly the increase in cement mills and in engineering schools has had the effect in each case of lowering the price of the product. But it is also true that this low price combined with excellent quality has enormously increased the demand, both the demand for cement and the demand for engineers.

Is the engineering profession overcrowded? Are its members underpaid? If you submit these questions to a jury of engineers, you will, I am sure, receive an affirmative v[illegible]. But I suspect you would have the same [illegible] of answer if you inquired of lawyers concer[illegible] the legal profession or of physicians as to [illegible] practice of medicine.

It is a fact, nevertheless, that [illegible]in changes in our educational system during [illegible] past half-century have operated to swell th[illegible]nks of the engineering profession above that [illegible] other professions, and by the competition th[illegible]et up have reduced the compensation of engi[illegible]s.

You will hear men blaming th[illegible] engineering schools for overcrowding the pro[illegible]ion. I do not think we can accept that criti[illegible]m offhand. I grant you it is true that many m[illegible] men have been graduated from our engineer[illegible] schools in the past twenty years than can fi[illegible]mployment in engineering work; but would it b[illegible]ell for the profession or for the country to h[illegible] it otherwise? Must we not frankly recogni[illegible] that of the men who graduate from our engine[illegible]ng schools every year, a very considerable pe[illegible]ntage are not fitted by natural ability to becom[illegible] successful engineers?

I have great sympathy for the many individual cases of hardship that result from the overcrowding of the profession. I freely subscribe to the statement that the engineering profession as a whole is not paid in proportion to the responsibility it carries and the useful service that it renders to the community; and yet I cannot believe it for the benefit of engineers or of the public to have the path into the engineering profession made too easy or the rewards for the lower grades of engineering work too great. The older men in the profession can recall times when there were not enough engineers to meet the demand, when any man who knew how to handle a transit could command a good salary as an engineer. Some of the recruits brought in at such times have been an injury to the profession and to the public. An injury to the profession because the work of incompetent men in any profession injures its reputation and limits its chances for profitable employment. An injury to the public because the public has to stand the loss and the disaster that result from engineering incompetence.

It is not, then, a conclusive argument against increase in engineering schools that the profession is overcrowded.

I yield to no man in honoring our profession. The best efforts of my life have been devoted to its advancement; but when the question is squarely put whether there are too many engineers, I am obliged to answer, there are none too many good engineers even though there be a surplus of poor ones. If engineers are underpaid, as I believe they are, it is because the public which employs engineers does not yet appreciate how valuable high-class engineering work is.

Somebody has defined the engineer as a man who can do with one dollar what any fool can do with two. When all members of the profession appreciate and act on that definition, the public can well afford to pay princely salaries to its engineers.

How many millions of dollars do you suppose might be saved annually in the United States if high-class engineering were substituted for mediocre engineering? Let me give you an example in just one single industry: steam power plants for generating electric current. One of the most prominent engineering firms in this country recently authorized the following statement: If good engineering were used in the design and operation of electric stations in the United States, a saving might easily be made of ¼-cent per horsepower-hour, and that would have amounted last year to no less than $[illegible],000,000.

I deprecate that competition in the engineering profession which lowers the pay of engineers. Competition in engineering ought not to be in rate of pay but on quality of service. A few days ago I received a letter from an official Board asking what would be a proper salary to pay an engineer for taking charge of a piece of hydraulic construction involving an expenditure of a million dollars. I replied that the salary

they should pay ought to depend on the sort of man they secured. If they engaged a man of exceptional ability he would probably save them so much on the cost of the work that they could well afford to pay him twice or thrice what they would pay an ordinary engineer.

I am not here to indict my own profession. Far from it. But every member of it who has reached mature years, held large responsibilities and come in contact with engineers of all sorts in actual work, will confess that a very large amount of work is done poorly that ought to be done well. That many, many millions of dollars are wasted that might be saved by better design, better supervision, better execution. Engineers, let us confess, are not exempt from the frailties of humanity. Some of us are lazy, and will take the easy course and let things run on in the rut of routine rather than make the effort to prepare new designs to meet changed conditions. Some of us are arrant cowards, and rather than run any risks we will spend money like water—so long as it is not our own money. I have seen engineers of this type take credit to themselves for their conservatism, and prate in official reports about the high-class construction they had secured, when the fact was that they had spent thousands where hundreds would have satisfied every requirement.

I am perfectly well aware that there are men who defend that type of engineering. They claim that an engineer's business is only to look after accuracy, strength, permanence and safety in construction, to use only the best materials and accept nothing but the highest class of work. It is engineers of this type who are responsible for the idea, still too commonly held, that to put an engineer in charge of work means a great increase in its cost. If we had less such engineering there would be a greater demand for engineers.

I am able to give you a personal illustration of the difference between the two types of engineering. Within 48 hours I have talked with men in Washington who know of the work your Director has done there in a great Government department of engineering work. He had the good sense to see that this work was only a means to an end; that accuracy and hair-splitting refinement were only valuable where they were effective in the final result. He solved the problem, "What is worth while" and his solution has saved the Government tens of thousands and probably hundreds of thousands of dollars.

I want to see more engineers who are able to wisely solve this problem, "What is worth while," in a hundred lines of engineering work.

How many hundreds of millions of dollars do you suppose are expended annually in the United States in the promotion of foolish and absurd inventions or enterprises wrongly planned? It has long been a theory of mine that people ought to be saved from losing their money in such schemes by seeking the advice of engineers. But I have found that before my theory can be put into practice we must have engineers who are wise enough and broad enough to give reliable advice on such matters. And the public must learn to discriminate between the engineers who know and those who only think they know.

I set forth these facts here for the encouragement of those who may be looking forward to the profession and who may have the feeling that engineering work has already reached such a stage of perfection that there is no room in it for further advancement or greater achievements. There *is* room and need to-day for better engineers and for a higher grade of engineering work.

And so your mill, although it is to grind out a staple product, is not designed to undersell the market. You are not aiming merely to increase the output of engineering graduates. Your President has clearly emphasized in his address that it is not cheap engineers but better engineering that the public needs.

Magnificent work has been done for the engineering profession by our colleges. I believe our American system of training men for the engineering profession is far in advance of that in vogue in any other country. We must recognize, however, that the rapid changes in science and industry and engineering make changes necessary in our engineering schools.

I have called your institution a mill which is to turn raw material into a finished product. Well, it is raw, sure enough, but let us remember that the material is alive—and let us hope very much alive. I believe, after all, your college is not a mill but—begging the pardon of the freshman class—a greenhouse.

Engineering education, like any other education worthy of the name, is a process of growth. To achieve success in your greenhouse culture you must have the right sort of plants to start with. Unless a boy has natural abilities of the right sort you cannot make him into a good engineer.

On the other hand, boys with good natural abilities who cannot afford a college training are going out into the working world all the time, beginning at the bottom rung of the ladder in some line of engineering industry, educating themselves in the school of daily experience, aiding that development by study in night schools and correspondence schools and by wide reading and observation.

I want to leave a wide door open into the engineering profession for the men who obtain their education in such a way. I want to deprecate any petty prejudice on the part of college-trained engineers against the engineers who have won success despite their lack of systematic college training. Such prejudice is as unworthy as that with which the so-called "practical" men met the engineering graduates of a quarter-century ago.

The engineering colleges to-day must recognize the aids that are now available to the boys outside of the college, in the shape of the correspondence schools for example. The question is, how shall the boy who spends four years or five years in the college achieve such growth that he can excel in competition the boy who has meanwhile been learning engineering by doing practical work.

For the past twenty years, the engineering colleges of the United States have been trying to answer this question by specializing their instruction in engineering, by multiplying the number of their courses, by trying to make men expert in one particular limited branch of engineering work. Now I am far from denying that there is a large demand and a certain field of usefulness for such special courses; but I believe the consensus of opinion among those best able to judge is that there has been too much specialization in our engineering instruction. We have to-day in the engineering profession many specialists, but too few men with broad knowledge, broad abilities and a broad outlook.

One common defect in your self-taught engineer is that, however proficient he may be in the one field where he has had experience, he knows little outside that field. It is the lot of most engineers to change their occupation many times in the course of a lifetime. One branch of engineering work falls off and they are obliged to turn to another. It is the advantage of the man with the broad college training that he can do this with facility. The specialist, however, when work in his specialty fails, finds his occupation gone.

Perhaps the error which is most to blame for the specialization in our college engineering courses is the error of assuming that the college education in engineering produces an engineer. The engineering graduate when he leaves the college halls is not yet an engineer, and would not be one even if you doubled the length of your course. There are indeed exceptions. An occasional young man of great ability and with a practical bent of mind will get enough out of his college course, supplemented by wide reading and vacation work, to be fit for considerable responsibility at graduation. But such exceptions only prove the rule. The college course in engineering is only laying a foundation on which the finished superstructure is to be erected through accumulated experience in actual work.

Now it may seem to some of you students a little disappointing to spend four or five valuable years and then only succeed in laying the foundation to become an engineer. But I want to assure you that it is in this very matter of foundation that the college-trained engineer has an advantage over his professional brother who "picks up" engineering. With a broad and deep foundation, there is no limit to the height of your superstructure and no limit to the speed with which you may erect it.

But the boy who starts in at engineering work when he leaves the common school is like one erecting a building and putting the foundation under it as he goes along. The job is not impossible, given patience and perseverance enough, but it takes a lot of both. Progress is slow, and the chances are that the man will be satisfied finally with a modest structure. Besides, foundations put in in this way are never quite as strong, never quite as reliable, as those built in the regular way. Sometimes such foundations fail and down comes the building.

The business of the engineering college, then, is to lay a broad, secure foundation. I am not objecting, mark you, to schools of a different sort. There is room and need for correspondence schools, for night schools, for industrial schools, for schools that may give special instruction in special fields. But if you aim to give an education to young men that will best fit them for high and responsible positions in the engineering world, then you must make your training a broad foundation.

And let me carry the simile one step further. You will find great difficulty in laying a secure foundation in a deep swamp or in fathomless quicksand. It will be a far better foundation if underlaid by rock or hardpan. So if you want to build a good foundation of engineering education, you must have to start with a boy of proper mental and moral and physical make-up. Now how will you restrict your work to such boys? That is, I think, one of the most difficult problems which our American colleges have to solve.

They are trying to solve this problem by raising their entrance requirements. They are trying to solve the other problem, how they may send out only high-class men into the profession, by increasing the work of the college course. These are probably necessary changes; and yet I want to sound one note of warning:

There is danger, I believe—and I am not alone in this belief—that you may shut out of your engineering courses boys who have natural abilities which fit them for success as engineers and yet are deficient in some branch of study, perhaps mathematics or the languages.

I do not underestimate the value to an engineer of either of these branches; yet I feel that they have been often overestimated in the framing of our engineering courses.

There is danger, if you place your emphasis too much on purely scholastic attainments in your engineering schools, that you may raise up a generation of scholastic engineers, expert in theory but weak in its practical application. The mathematical side of the profession and even the research laboratory have been if anything overdone already. We must lay broader foundations than these typify if your graduate is to successfully compete with his rival, educated in the school of hard knocks. A broader training than this is needed if your engineer graduates are to meet the demands of this twentieth century.

Do you say, what are these demands? I want to impress upon you that the country to-day needs engineers of high type as it never has needed them before. Few realize the enormous change that has taken place in the relations between the engineer and the public. Go back less than a century—no longer ago than the lifetime of men still living—and you find the engineer almost unknown. Civilization and industry knew his prototype—the millwright, the builder, the miner; but their art was the art handed down by tradition, crusted over with superstition and error. The application of science and the scientific method to industry had barely begun.

Go back half a century and we have the beginnings of engineering; the railway, the steam-

ship, the development of the mine and the waterfall. There were great men among the engineers of those pioneer days. We do well to honor their achievements. Yet the problems of that day, seen in our present light, were simple. The engineer was a necessity in very few industries. His art was not yet so complicated that it could not be mastered by the diligent student with little aid in the way of text-book or teacher.

But the period since the Civil War, and particularly the latter half of that period, has seen social, economic and industrial revolutions, such as the world has never before witnessed. Civilization finds itself face to face with a multitude of perplexing problems. And a very large number of these problems are so interwoven with our industrial development that the engineer is needed to aid in their solution.

I have told you that engineers are needed to effectually solve the problem, "What is worth while." Is it worth while to spend two hundred million dollars to build one kind of a lock canal at Panama, or three hundred millions to build the one we are now completing, or five or six hundred millions to build a sea-level canal? Is it worth while for the Government to spend half a billion dollars on waterway improvements? Is it worth while for a state to spend a million or ten millions on good roads? How much ought a city to spend on sewage disposal? on water purification? on lighting its streets?

I know engineers who shirk these questions; who say that the engineer should take a humble back seat while the statesman, the lawyer, and—if you please—the ward alderman decide these questions.

I tell you, gentlemen, this is a huge mistake. Our statesmen and lawyers and aldermen—even when they are honest and well-meaning—are sadly lacking in knowledge, except it be that little knowledge which is proverbially so dangerous.

For lack of wise engineering leadership the public is being led to-day toward many an unwise and wasteful expenditure. Men are going up and down the land to-day fostering fallacies and errors—errors which will directly affect our national welfare unless good sense and good judgment can be invoked to correct them.

No student of history can fail to be impressed with the importance to a people of able leaders. The prosperity of our own favored nation rests no more certainly on natural resources and on an intelligent and law abiding people than it rests on wise leadership. The opportunity for leadership is open to the engineer. His technical knowledge is essential to the wise solution of public problems. Can he couple with his technical knowledge those other qualities which are essential if the public is to be safely guided?

And what are some of these qualities? Well, I would name first of all what I may term the judicial spirit. An engineer has no business to be governed by prejudice or partisanship. His sole object ought to be to find where the truth lies. He must constantly make choices in his daily work, and sound judgment in such choices is a first requisite. Of course he must have the knowledge on which to base a judgment; and yet when I am asked to recommend an engineer for large responsibilities, I look first of all for a man of broad mind, one who is able to weigh matters fairly and judge without prejudice. Even though such a man be compelled to rely on others for some part of the technical knowledge required, he is a safer counselor by far than a man of small caliber, though the latter be loaded to the muzzle with facts and theories.

The public has some reason for distrusting the judgment of so-called experts. If your expert has been a man of one idea too long, there is danger that his grasp of broad principles may be deficient and that his judgment may be warped.

Can you develop in your students who go out from this institution those qualities of mind and heart and character which will in later years ripen into sound judgment? If they gain such development from their college training they will gain something much more rare and valuable than knowledge of hydraulics or expertness in the testing laboratory.

Does it seem to you impossible to cultivate in your college course such personal qualities as the judicial spirit? I grant you that a proper mental equipment in the student is essential at the start; but given that, ought not the college years—the formative period of a man's life—to be effective in cultivating just such qualities? Do not our American colleges and universities miss their highest opportunity if they fail to develop in their students a broad outlook, fair-mindedness, keenness to discern error, love of the truth?

I have emphasized the need of engineering leadership. But the essential to leadership is the ability to deal with men.

Every engineer of long experience knows that the ability to write a clear report or a strong letter, to speak forcibly and convincingly, either to one man alone or an audience of hundreds—ability to do things like these is as valuable to an engineer as technical knowledge. Training in writing and in speaking is being emphasized more and more in our engineering courses.

And there are other qualities that make for leadership: Tact—the combination of good judgment with good taste in dealing with others; self-confidence without self-conceit; a personality that attracts men, wins their confidence, holds their loyalty. It is qualities such as these that make the leader of men. It is such choice qualities as these that the atmosphere of our universities ought to develop in their students. Was it not with such high ends in view that our universities were founded?

Your splendid new building has higher purposes than a mere mill. You will not rate its success in dollars and cents of annual profit. And I want to protest against the too-common standard by which we rate the success of men. You tell me that this graduate holds a $25,000 position, that another owns a rich copper mine and a third is president of a colossal trust. Have they achieved success? Very likely; but why not apply to them the same standard that we apply to your university?

The true measure of success, alike for the university and for its graduates, is the test of public service.

I know an engineer who has through long years guided the destinies of a great city, saved to its taxpayers untold millions of dollars, fostered its development in a way that will benefit generations yet unborn.

I know an engineer who dared to risk his professional reputation and his life to uncover fraud upon the commonwealth and punish the guilty.

I know an engineer who has turned a barren desert into fruitful farms and has made possible prosperity and happiness to thousands and tens of thousands.

It is true that the public seldom appreciates the value of such services as these and those who render such service often receive only meager reward; and yet I tell you that it is achievements like these that best deserve the name of success.

Shall we not, then, dedicate your new building to the culture of such high ideals? Within its walls may all noble traditions, all honorable standards, be fostered and upheld. May those who go forth from its influences carry with them a rich spirit of loyalty—loyalty to the public welfare, loyalty to their city, their commonwealth, their country. So will they justify those who to-day dedicate this building to public service.

A Philippine Mud Slide.

By C. G. WRENTMORE,* Assoc. M. Am. Soc. C. E.

Mount Banajao is an extinct volcano in the Province of Tayabas, southeast from Laguna de Bay, and about midway between the latter and the south coast. The town of Sariaya lies southeast from the mountain and about five miles from its foot, while Candelaria lies at about the same distance to the southwest. The highway connecting the two towns crosses three branches of a river, all of which branches come down from the mountain and unite a short distance south of the highway, running from this point to the sea. The coast is about five miles from the highway and is parallel to it.

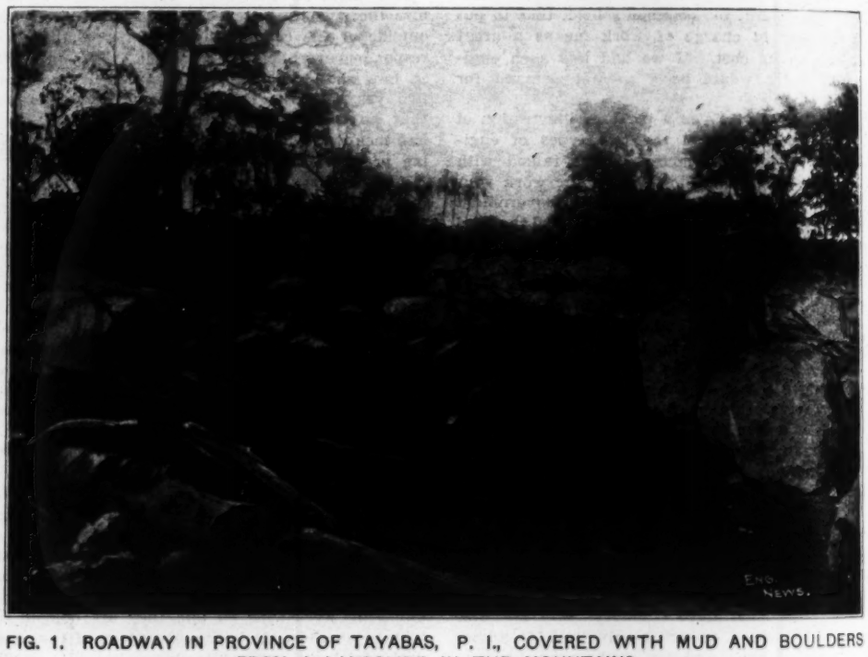


FIG. 1. ROADWAY IN PROVINCE OF TAYABAS, P. I., COVERED WITH MUD AND BOULDERS FROM A LANDSLIDE IN THE MOUNTAINS.
(View looking east along roadway from west stream.)

On the evening of Jan. 17, a violent storm passed over this district and, in the morning, it was found that the highway for a distance of two miles was covered with mud, that all bridges had been swept away and that a very large amount of damage had been wrought. An examination showed the following facts.

Some time previously an American had visited the mountain and found that a heavy land slide had choked a gorge on the south slope and that water in the gorge was ponding up behind the dam thus formed to a considerable depth. Heavy rains for a considerable period had been gradually filling this pond until it finally forced out the dam on the evening of Jan. 17.

The accumulated mass of water and loose earth, in passing down the gorge for a distance of five miles before debouching on the plain, was thoroughly mixed into a uniform thin mud which flowed almost as freely as water. On striking the comparatively level ground, it spread out

*Assistant Director of Public Works, Manila, P. I.

over the central valley each way to the eastern and western streams, and flowed down all three valleys, wrecking everything which it touched, and not stopping until it reached the sea.

From the foot of the mountain to the sea is a distance of ten miles, and it is estimated by the writer that the average width covered is approximately one-half mile. The average depth of mud deposited can only be roughly estimated,

FIG. 2. ONE OF THE TWO TRUSSES OF THE 75-FT. BRIDGE SPAN WRECKED BY MUD SLIDE IN THE PHILIPPINES.

but is probably in the neighborhood of 12 ins., which would account for approximately 9,000,000 tons of material.

The mud brought with it large quantities of boulders, remarkably uniform as to size, the greater portion of them being from 3 to 4 ft. in diameter, with occasional specimens up to 15 or 20 ft. in greatest dimension.

The heaviest deposit of rocks was on the upper reaches of the plain, but large quantities were carried well below the road. On the road itself, the total width between the extreme east and west points touched by the mud is approximately two miles, and, within this distance, 4,600 ft. in length of road were covered by the mud, the depth on the roadway averaging approximately 1½ ft.

A 75-ft. steel bridge which spanned the eastern-most of the three streams was swept away, the bed of the stream filled up and the stream itself diverted so that it crossed the road at a point 500 ft. to the east of its former location.

The greater portion came down the central stream, where the path cleared by the mud varies in width from 300 to 1,200 ft. Strange to say, no lives were lost, although a number of houses were carried away and a considerable number of carabao and many wild animals were killed.

The accompanying photographs will give some idea of the situation. These photos were taken three weeks after the slide occurred and Fig. 3 shows in a very interesting way the flow of the mud, which must have been of the consistency of soft mortar. The lines shown are not caused by water, but are caused by the flow of mud itself. The boulders in the foreground are from 3 to 4 ft. in diameter and the depth of mud at this point is approximately 2 ft. The foot of the mountain shown in the background is approximately three miles from the point where this photograph was taken.

CHEAPER RADIUM is promised by the discovery that the ash of a lignite found in Sweden contains radium which can be extracted by an inexpensive process devised by a chemist named Hellsing. The "Schweizerische Bauzeitung" quotes Prof. Arrhenius and Prof. Anderson of the Geological Survey of Sweden as approving the Hellsing process.

A Neglected Splice for Timber Tension Members.

By ROBERT FLETCHER, Ph. D.,* Assoc. Am. Soc. C. E.

Although the splicing of timber might well be considered a subject of little interest in these days when bridges and buildings are built chiefly of steel or reinforced concrete, there yet remain old Howe truss bridges needing reinforcement; and, in sections of the country where timber is yet abundant, the Howe and lattice trusses are still justifiable in new construction. Not many years ago standard designs and specifications for Howe truss and combination bridges were adopted and promulgated by the Chicago, Milwaukee & St. Paul Ry. and by the Oregon Pacific Ry.† A notable paper on timber bridges on the Boston & Maine Ry. system appeared not very long ago.‡ And a noteworthy instance of the ingenious use of a Pratt truss, chiefly of wood, for auxiliary service was recently seen at the 22d St. crossing of the Chicago River.*

While the tension splices in such structures show some degree of uniformity in design, there is sufficient variety to call for remark, especially as some more recent devices show much misdirected ingenuity in producing joints which are not only far more complicated than older forms, but

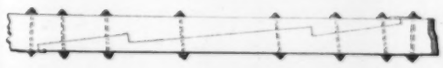


Fig. 1. The Ordinary Scarf Splice.

distinctly inferior, as respects cost, certainty of action and possibility of correct adjustment. In the interest of economy, simplicity and more correct practice, the writer would call attention to an old form of splice which, with at least one notable exception, has been generally ignored, and which deserves rescue from "innocuous desuetude."

Recalling the principal types in general use we note first the inefficient scarf joint (Fig. 1). This has been much used by carpenters and builders and theoretically develops half the strength of the stringer, but the stresses at the notches not being

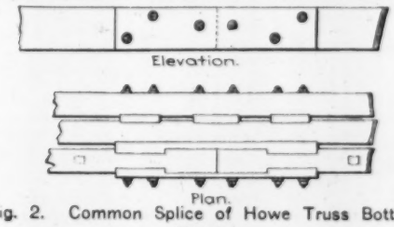


Fig. 2. Common Splice of Howe Truss Bottom Chords.

in the same straight line form a twisting couple. Also, due proportions require a length about fifty times the depth of one notch.

The well known block-splice for the lower chord of Howe truss bridges (Fig. 2) has probably had the widest general use, but is sometimes badly proportioned, is often made with only one splice-block, and more rarely with such utter disregard of the vital importance of the joint that cross-grained and knotty wood is put in the blocks or in the main timbers near the notches. On some Howe truss bridges in the Southern States the builders put the splices at the panel points and actually *bored through the splice-blocks*, nearly cutting them in two, to give place for the vertical rods.† The failure of some of these bridges was

FIG. 3. FLOW OF MUD IN RIVER CHANNEL IN THE PHILIPPINES FOLLOWING A LANDSLIDE IN THE MOUNTAINS.
(Looking north up the main stream toward Mt. Banajao.)

*Director of Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H.

†Engineering News, Vol. 23, April 26, 1890. Also Framed Structures, by Johnson, Bryan, and Turneaure, Ed. 1905, Chap. 23.

‡By J. P. Snow, Mem. Am. Soc. C. E., Bridge Engr., B. & M. Ry. In Jour. Assoc. Eng Soc., July, 1895.

*Engineering News, Vol. 54, page 698, Dec. 28, 1905. Also do, Vol. 48, page 125, Aug. 21, 1902, Howe truss foot-bridge, Chicago River.

†See Engineering News, Vol. XXX., 376, No. 9, 1893.

a necessary consequence. About twenty years ago the writer, being called upon to report upon an old Howe truss bridge on a transcontinental through freight line in Northern New England, found that nearly every splice in the lower chords had pulled apart, so that only the momentary resistance of the splice bolts had prevented complete wreck of the bridge. This occurred in the early history of the structure, which had been patched and then changed to a three-span bridge by trestle supports. Inquiry elicited testimony that the workmanship on the splices was so bad as to cause common remark when the bridge was

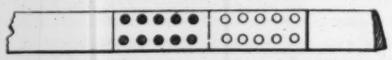


Fig. 3. Fish-Plate Splice; Has High Ultimate Strength But Low Yield-Point.

built. In another instance of a Howe truss bridge of 200 ft. clear span over a celebrated gorge of one of the tributaries of the Connecticut River, the writer found many of the lower-chord splices split and useless, so that the structure had a sag of about 4 ins., and it was a question how to save it. Here the application of the simple splice to be described solved the problem.

In some tests made years ago, under direction of the writer to get comparative results from carefully made models on a reduced scale, the fish-plate splice (Fig. 3) was found to have the greatest ultimate resistance, but it gave way when the pull was only about one-fourth of that of rupture, that is at the point where the friction induced by the pinch of the bolts ceased to be effective. This is the form used in the Chicago draw-bridge just referred to. The objections to it are obvious: (1) the resistance is entirely by the bearing reaction of the wood against the bolt in the bolt-hole; (2) this requires from 20 to 30 or more bolts for an ordinary splice, and, as these extend through the entire width of the chord, the aggregate length may be 40 to 50 ft. for a single connection; (3) all the holes must be bored through the adjacent unspliced stringers, thus cutting a very large proportion of the fibers of the whole sticks.

But the standard plans for the Pacific Coast lines before mentioned show splices more complicated and difficult for the builder to execute than the older forms. In one case there are four cast-iron plates, two on each side of the joint; each plate has cast on the inside 21 round projecting dowels or fingers to be fitted into 21 corresponding holes bored in the timber; so that a total of 84 holes must be bored with the idea that the pressure will be evenly distributed upon the 84 projections of the plates.* Finally, the stress is carried past the joint by a clamp bar on each side, 6 ft. long, tightened or adjusted to full bearing by a steel wedge. To say the least it must be quite difficult to construct such a splice so as to realize the ideal efficiency, and the constancy of its adjustment is open to serious question.

Another contrivance consists of eyebars, special bearing-plates, pins and eccentrics intended to be keyed up to effective action;† but supposing the ideal conditions could be practically realized, the percentage value of the splice is hardly high enough, even if computable. Either of these forms is undesirable in respect to the number and various shapes of the parts, and is costly in both amount of workmanship and material required.

The simple splice to which attention is now called is an old form, and its construction, shown in Fig. 4, is so obvious as to need no explanation. The action between the lug or bar and the fiber ends of the wood in the mortise hole is definite and computable; the wood between the hole and the end of the stick resists by double shear; the wood between the hole and sides of the stick has its full value in tension; the two bolts need not be of disproportionate size to transmit a stress equal to half the strength of the uncut stringer; and the wrought-iron or steel tenon bar may be made stiff enough to resist undue bending at the edges of the mortise and thick enough to be safe against shearing at the bolt holes. The carpenter work is a small fraction of what is required for any of the other forms described, and even the labor of cutting the mortise holes may now be abridged by the new tool for boring square holes.*

In the case previously mentioned where the failure of a long-span Howe truss bridge was threatened by the rupture of many of the block splices of the lower chords, the writer designed such lug-and-bolt splices to bring the useless string pieces again into action, and they were applied with complete success. The increase of the sag was immediately stopped, and the Superintendent reported a remarkable improvement in the stiffness and general behavior of the bridge. The dotted lines in Fig. 2 (Plan) indicate the proper location of mortise holes for the lug-and-bolt splice, when applied for reinforcement.

This form of splice has been adapted to narrow timber such as the plank in wooden lattice bridges, by Mr. J. P. Snow, M. Am. Soc. C. E., as described in the reference already given. He uses wrought-iron lugs, thin enough for 3-in. or 2½-in. plank and so wide as not to bend appreciably, and makes the connection above and below by horizontal yokes or long U bolts, which embrace the ends of one lug above and below the stick and are secured to the ends of the other by nuts working against transverse bearing-plates.

Obviously it is necessary to have two ¾-in. chord bolts between each mortise-hole and the end of the stick. These, with extra long packing-blocks between all of the chord stringers at this point, will resist the warping and checking of the timber near the lugs, and bind the chord together across its entire width.

The economy of this joint over the block splice

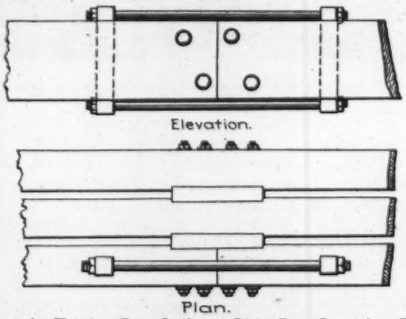


Fig. 4. Tenon Bar Splice; Old, But Superior To Others, and Well Adapted for Reinforcing Defective Splices in Existing Bridges.

may be questioned, because, although it requires only half as many chord bolts, the greater weight of iron in the lug bars and thick bolts may offset the saving of manual labor in the making of it. But it is always more compact—shorter because the wood resists by double shear, and narrower because there are no splice blocks. If in cost it is simply on an equality with the block splice, in other respects it is far superior to all other types noted, viz.: in simplicity, directness of action, and certainty in the computation of its working value. But, above all, it is less liable to be defective through careless workmanship, because, the essential parts being only two lug bars and two bolts with their nuts, the adjustment does not depend upon nice fitting of surfaces, and even a stupid artisan would hardly leave it before bringing the parts into proper bearing. "A word to the wise is sufficient."

*Theory of Framed Structures, before referred to; Chap. 23, plate III.
†Same, plate III-A.

Costs of Triangulation and Topographic Surveys, U. S. Reclamation Service.†

During the spring of 1908 a triangulation system consisting of 48 signals and controlling about 150 sq. miles, was installed on the Grand Valley Project, and during the field season of the same year a plane table survey of approximately 127 sq. miles was made and maps prepared on a scale of 1 in. to 1,000 ft. with 10-ft. contour intervals.

A careful record of expenditures was kept and the itemized costs are shown in the accompanying tables.

In the triangulation survey the signals consisted of 2 × 4-in. posts 14 ft. high, erected over pieces of ¾-in. gas pipe driven from 18 to 24 ins. in the ground and held erect by three guy wires to each post. The signals were arranged 2½ miles apart and where ... required more frequently or section ties ... outside of the area mapped the charge for ... made against the topographic mapping. ... triangulation survey shown include the ... ing base lines and of making Polaris ob... camp was established and subsistence w... hotels and farm houses in the vicinity.

COST OF TRIANGULATION SURVEY, ... LEY PROJECT.

Distribution	Average time per sq. mi., days	Rate per ...	Cost per sq. mi.
Transitman	0.11	$7...	$0.80
Transitman	.14	...	.46
Office engineer	.05	...	.14
Recorder	.05	...	.15
Flagman	.25	...	.56
Computer	.05	...	.12
Draftsman	.01	...	.02
Hired horses	.08	...	.04
Government horses (depreciation)	.40	...	.10
Depreciation of equipment	....	...	.03
Travel	....	...	.05
Subsistence	....	...	.29
Supplies, miscellaneous	....	...	.18
Supplies, stakes and monuments	....	...	.45
Supplies, repairs	....	...	.02
Supplies, forage	....	...	.22
Total cost per square mile			$3.63

In the plane table survey the field party usually consisted of one plane table man, one recorder and two rodmen, but at times a drive was necessary for teams used by level and topographic parties. The camp teamster hauled the supplies necessary, but the men furnished their own subsistence by organizing a club. The cost of hay was $15 per ton and of oats $1.80 per hundredweight. The area mapped was fairly rough on the average, but the cost was quite variable. On level mesa the cost was as low as $18 per sq. mile, but where the area mapped consisted of small fruit farms with numerous buildings, roads, fences and irrigation and waste ditches, the cost ran as high as $75 to $80 per sq. mile.

COST OF PLANE TABLE TOPOGRAPHIC SURVEY, GRAND VALLEY PROJECT.

Distribution	Average time per sq. mi., days	Rate per day	Cost per sq. mi.
Project office expenses	....	....	$1.63
Transitman	0.02	$3.33	.07
Flagman	.02	2.00	.04
Levelman	.47	3.00	1.41
Level rodman	.51	2.25	1.15
Driver	.31	2.00	.63
Topographer	2.90	3.00	8.69
Recorder	3.06	2.25	6.90
Stadia rodman	6.15	2.00	12.32
Hired horses	5.83	.50	2.92
Government horses (depreciation)	4.84	.25	1.21
Computer	.45	2.25	1.02
Draftsman (chief of party)	.58	3.33	1.93
Camp cook and teamster	3.70	2.00	7.41
Depreciation of equipment	....	....	2.68
Veterinary service	....	....	.04
Supplies, miscellaneous	....	....	1.28
Supplies, stakes and monuments	....	....	.63
Supplies, repairs	....	....	.51
Supplies, forage	....	....	4.50
Supplies, shoeing	....	....	.39
Traveling expenses for field party	....	....	.02
Subsistence for field parties remote from camp	....	....	.41
Total cost per square mile			$57.79

The 42d St. Bridge, Philadelphia, Pa.; An Arch With Steel Ribs Filled Between With Concrete.

On the line of 42d St., where it crosses the tracks of the Pennsylvania R. R., the city of Philadelphia has now in course of construction a combination steel and concrete arch highway bridge, of a unique type, the leading peculiar features of which are the double steel arch ribs enclosing concrete, a concrete covered floor system and the novel method of closing the hinges of the arches. On account of the low grade of the approaches above the tracks which the bridge crosses it was impossible to build an arch with superposed floor, so that the ordinary masonry or reinforced-concrete arch was impracticable, and the city, as far as it is able, is avoiding the old type of flat steel trusses, so the arch with suspended floor seemed the best solution for the crossing problem. This general type having been decided upon, the various novel features of the design were afterward developed. The contract for the construction was awarded in the summer of 1908, and the construction of the abutments has now been completed and the steelwork fabri-

*Engineering News, Vol. 61, p. 24, Jan. 7, 1909.
†From the "Reclamation Record," May, 1909.

cated. It is expected that the work will be completed before next autumn.

The 42d St. bridge consists of two so-called semi-hinged arch ribs, 37 ft. 6 ins., c. to c., and of 262 ft. span, center to center of bearings. Suspended from each of these ribs by 12 steel hangers is a floor system of structural steel members, is to be filled with concrete, placed, with small stone aggregate, through openings provided in the upper cover plate, which openings are to be closed by plates furnished with flat-topped tap-screws, after the concrete has been deposited. The concrete depositing is to start at the lowest opening on the ring and each opening is to be taneously on opposite sides of the middle, and continuously for each rib from start to finish.

As will be shown later, the concrete between the ribs is expected to take a proportionate part of that portion of the load applied after the depositing of the concrete, so it is very necessary that all voids between the ribs be filled.

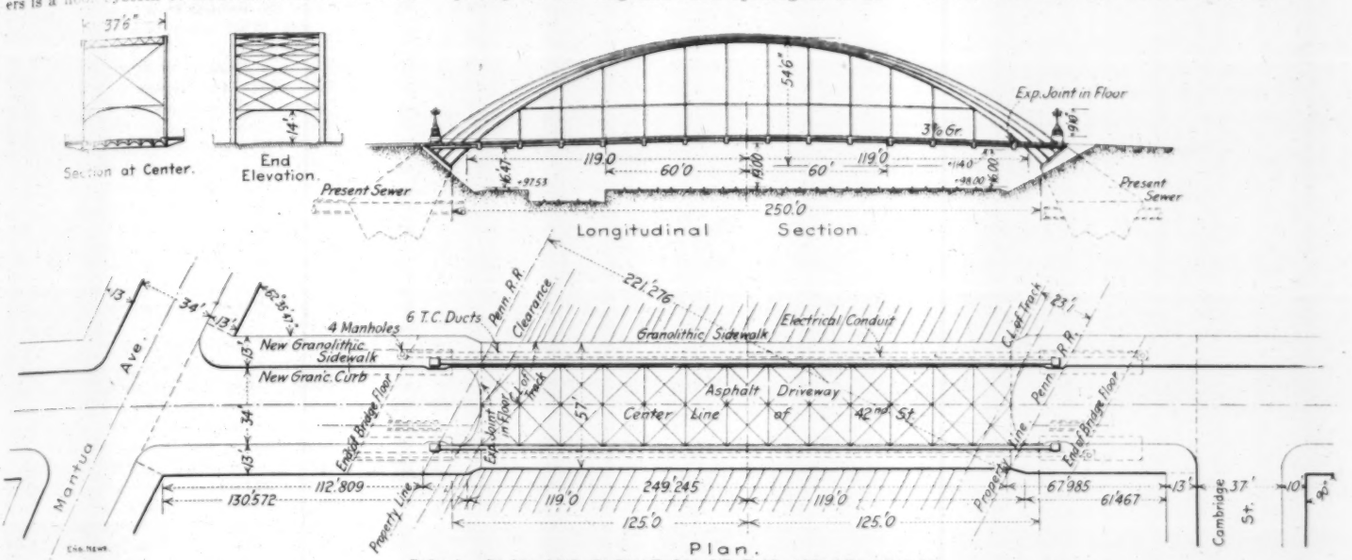


FIG. 1. PLAN AND ELEVATION OF THE 42D ST. BRIDGE.

completely inclosed in concrete, and carrying two granolithic sidewalks and an asphalt driveway, designed to carry street railway tracks, though for the immediate future such tracks are not projected.

The arch ribs are designed with the extrados a 200-ft. radius circle running into a tangent near the spring, and the intrados a parabola. They are 3 ft. deep at the crown and 10 ft. 6 ins. at the spring, the curve between being so disposed that the line of pressure always keeps within the middle third and under maximum conditions of loading approaches the neutral axis of the ribs. Each of the ribs consists of two plate girders, built up of a 11-16-in. web plate, strengthened with four longitudinal lines of angles and connected by top and bottom cover plates of uniform thickness throughout the rib. These webs are spaced 15 ins. clear, and in addition to the cover plates are provided against external bulging, with lines of ⅞-in. staybolts, as shown in Figs. 2 and 4. Between the webs, the 15-in. space thereafter successively closed when the wet concrete, poured in the next highest opening, begins to run out. This successive filling compels a certain slowness in the laying of the concrete which will prevent a too heavy hydrostatic pressure, at the same time providing continuous concreting, so that the interior filling will be monolithic.

The specification on this concrete depositing reads as follows:

> The ribs shall be filled with concrete through 5-in. holes in the top cover plates at points to be designated. This concrete shall have no stone larger than will pass a ⅞-in. ring, and it shall be mixed very wet and thoroughly rammed with iron rods and jarred with wooden mallets, the operation of filling being carried on simul-

HINGES.—Each rib is spliced in three places between crown and spring, at which latter three points erection hinges are placed. These hinges are finally closed in the manner to be herein described, which closing gives to the ribs the term "semi-hinged" applied by the designers.

All steel work is to be erected on staging and bolted at the splices, no rivets being placed until the centers are lowered. The crown ends of each half arch rib are reinforced with additional angles and plates and closed across the end with a plate, planed to face on the upper side. According to the design the planed face of this plate is to come 1-in. from the center line, thus allowing a 2-in. opening to be filled at the crown for keying. However, to provide for possible discrepancies in erection, allowances are made for at least a 4-in. opening at the crown and enough fillers are provided to make this adjustment. These filler plates are 16 ins. deep and 25 ins. wide and of varying thicknesses. They are provided with holes for ten bolts which

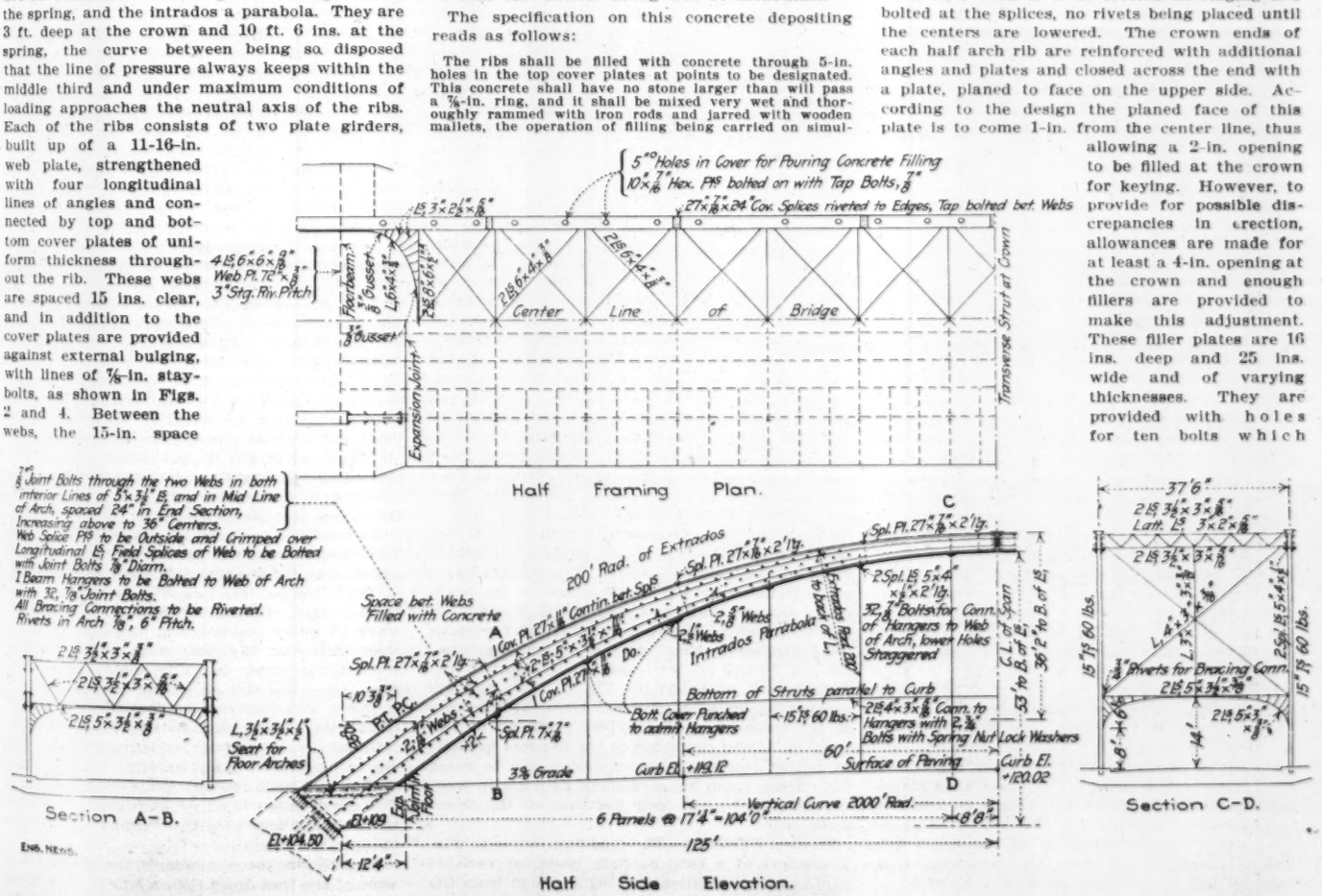

5" Holes in Cover for Pouring Concrete Filling
10" x 7/16" Hex. Plts bolted on with Tap Bolts, 7/8"
27" x 7/8" x 24' Cov. Splices riveted to Edges, Tap bolted bet. Webs
Center Line of Bridge
Transverse Strut at Crown
Expansion Joint
Half Framing Plan.
7/8" Joint Bolts through the two Webs in both interior Lines of 5" x 3½" Ls, and in Mid Line of Arch, spaced 24" in End Section, Increasing above to 36" Centers.
Web Splice Plts to be Outside and Crimped over Longitudinal Ls. Field Splices of Web to be Bolted with Joint Bolts ⅞" Diam.
I Beam Hangers to be Bolted to Web of Arch with 32, ⅞" Joint Bolts.
All Bracing Connections to be Riveted.
Rivets in Arch ⅞", 6" Pitch.
Space bet. Webs Filled with Concrete
200' Rad. of Extrados
Intrados Parabola
Bottom of Struts parallel to Curb
Bott. Cover Punched to admit Hangers
Seat for Floor Arches
3⅜ Grade
Curb El. +119.12
Surface of Paving
Curb El. +120.02
Vertical Curve 2000' Rad.
6 Panels @ 17'4" = 104'0"
125'
Half Side Elevation.
Section A-B.
Section C-D.

FIG. 2. DETAILS OF ARCH RIBS AND BRACING.

will pass through them connecting the ends of the arch sections, and will serve to transmit the arch shear without depending upon the friction of the key. Should the faces of the key space be found to be not parallel, the last filler plate will be planed to the required wedge shape to fit the space to ensure equal bearing and axial transmission of the pressure. Experiments were made with the metal zinc to determine its suitability for keying by pouring it in a molten state into the space, but it was found that if the metal has any positive elastic limit it must be so low that it would not perpetually resist the service load in this case which is 4,000 lbs. per sq. in. Although the metal can stand a momentarily applied load of 8,000 to 10,000 lbs. per sq. in., the elastic limit is so affected by time loadings that test pieces left in the testing machine over night show a compression under as low a load as 2,000 lbs. per sq. in. On account of this weakness it was discarded.

It will be seen that the hinge at the crown is 16-ins. deep, or a little greater than one-third of the total depth of metal at the crown, so that while not confined to a single point as in a truly hinged joint, the line of pressure is limited in its variation and at the same time a suitable adjustment for erection is provided. This final adjustment of the crown hinge is made subsequent to a temporary adjustment of the spring hinges but the final closure of the hinges is made at the springs as described in the next paragraph.

At the spring the hinge is of somewhat different construction. There the concrete abutment is laid to the angle of skewback, with the bed of that skewback formed by a transverse line of 20-in., 80 lbs. I-beams, embedded in the concrete with their upper surfaces just protruding. These beams are disposed as shown in Figs. 3-4, six at each of the outer edge and two in the middle, each group being joined in itself by bolts and separators and entirely independent of the adjoining group. During the erection of the ribs the spring bearing is to be upon the middle group of two beams, through cast zinc blocks 6 × 28 × 1¼-in. in size. After the arch ribs are keyed at the crown and the steel work bolted together and swung but before the concrete is placed anywhere on the bridge, the line of pressure will run at about the middle of this bearing. At this time then, and when the external temperature is near the mean of the year, the final closing of the joint is to be made by driving at each of the 12 outside beams, between the beams and the base of the rib, a pair of 7 × ½-in. steel wedges, until the wedges take an even bearing. During the construction of the arch the ribs are secured to the skewback by anchor bolts, but as soon as the wedges are placed, each set of wedges is to be secured to the base plate by tap bolts. The steel work will then be riveted up and the concreting started.

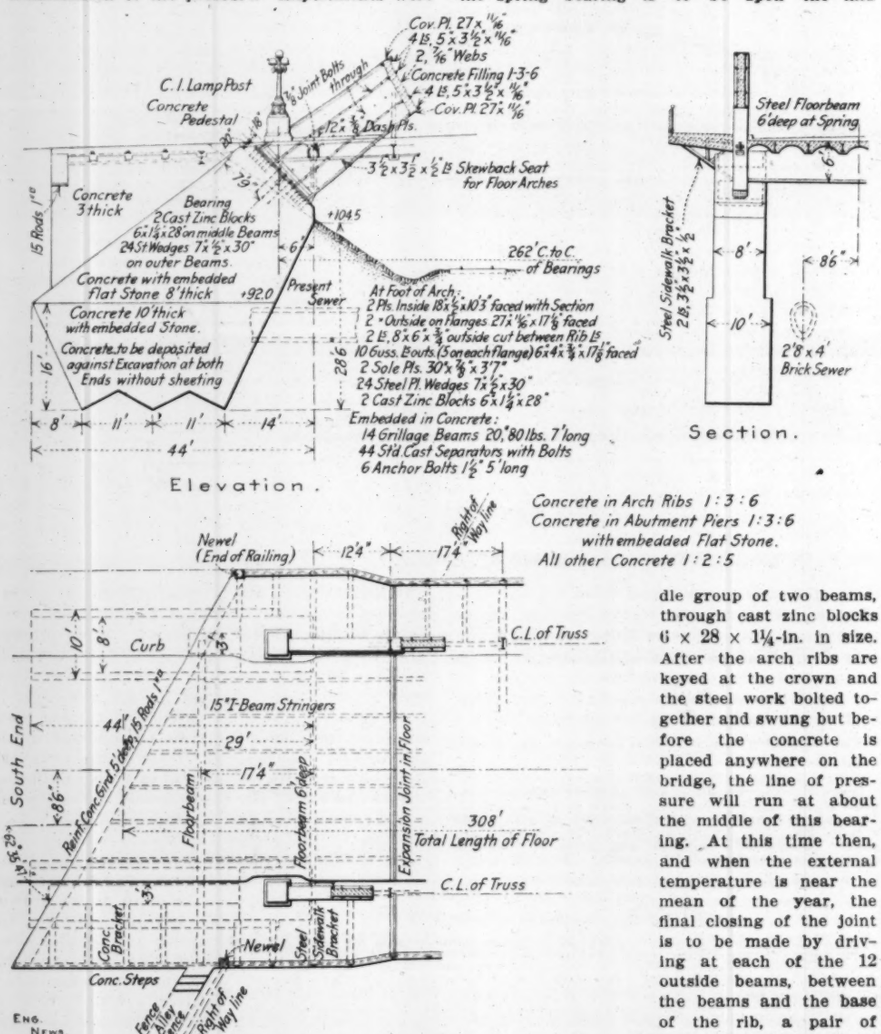

Cov. Pl. 27 x 11/16"
4 Ls. 5 x 3½ x 11/16"
2, 7/16" Webs
Concrete Filling 1-3-6
4 Ls. 5 x 3½ x 11/16"
Cov. Pl. 27 x 11/16"
C. I. Lamp Post
Concrete Pedestal
8" Joint Bolts through
12" x ⅜" Dash Pls.
3½ x 3½ x ½" Ls Skewback Seat for Floor Arches
Concrete 3' thick
Bearing 2 Cast Zinc Blocks 6 x 1¼ x 28" on middle Beams
24 St. Wedges 7" x ½" x 30" on outer Beams
Concrete with embedded Flat Stone 8' thick
Concrete 10' thick with embedded Stone.
Concrete to be deposited against Excavation at both Ends without sheeting
15 Rods 1"
+104.5
+92.0
Present Sewer
262' C. to C. of Bearings
At Foot of Arch:
2 Pls. Inside 18" x ⅜" x 10'3" faced with Section
2 "Outside on Flanges 27" x 1⅛" x 17⅛" faced
2 Ls. 8" x 6" x ⅜" outside cut between Rib Ls
106 uss. Bolts (5 on each flange) 6" x 4" x ⅜" x 17⅛" faced
2 Sole Pls. 30" x ⅜" x 3'7"
24 Steel Pl. Wedges 7" x ½" x 30"
2 Cast Zinc Blocks 6" x 1¼" x 28"
Embedded in Concrete:
14 Grillage Beams 20" 80 lbs. 7' long
44 Std. Cast Separators with Bolts
6 Anchor Bolts 1½" 5' long
8' 11' 11' 14'
44'
Elevation.
Steel Floorbeam 6' deep at Spring
Steel Sidewalk Bracket 2 Ls. 3½ x 3½ x ½"
8'
10'
8'6"
2'8" x 4' Brick Sewer
Section.

FIG. 3. DETAILS OF ABUTMENT AND SKEWBACK.

HANGERS.—The hangers which carry the floor system are placed as shown on the figures. They are made of 15-in. I-beams so that they just fit between the two plates of the arch rib and are riveted thereto both by direct rivets and by short longitudinally placed angles. The bottom cover plate of the rib is cut to the shape of the beam (Fig. 4), so that no appreciable amount of the wet concrete can leak out through the opening during depositing. At the bottom, the hangers are riveted to two upstanding plates of the floor beams, as shown in Fig. 5. The hangers are braced by a longitudinal piece, at the level of the roadway sway bracing, made up of two 4 × 3-in. angles connected to the hangers by bolts in slotted holes, so that expansion can be cared for. These beam hangers serve as posts in erection to support the arch sections on the falsework.

FLOOR SYSTEM.—The roadway shown in Fig. 5, consists of a built-up floor beam, of variable depth and composition, carried as noted from the hangers, and in turn carrying I-beam stringers between which are sprung jack-[illegible]hes of solid concrete. In addition there is a [illegible]oncrete covering around the entire steelwork o[illegible]he floor system, covering the bottom of the [illegible]beams by a minimum thickness of 3 ins. [illegible]is concrete is to be placed at the same [illegible]me as the jack-arches, small steel rods being [illegible]wed around the bottom of the flanges to incre[illegible] the bond to the steel work. This concrete co[illegible]g has been used with considerable success [illegible] the city of Philadelphia in a number of bridg[illegible]across railway tracks, where the smoke an[illegible] gases from locomotives tend to corrode the [illegible]earby steel work in the old steel bridges. The [illegible]concrete-covered steel floor systems are compa[illegible]tively cheap and easy to erect and are quite cor[illegible]sion proof.

In this floor system an expansion [illegible]oint is provided where the floor joins the arch [illegible]ib on either side. This joint is shown in detail in Fig. 5. Beyond that point the floor is supported by a floor beam attached directly to the arch rib and then by beams supported on the abutment. The floor itself has a camber of a 3% curve both sides up to the middle.

TRANSVERSE BRACING.—To provide for transverse stiffness there is a double system of sway bracing. This consists of a trussed horizontal brace between the ribs themselves, which are joined by light diagonals to the lower arched bracing immediately above the roadway. The floor system is considered of sufficient stiffness for a lower lateral system, so that no additional steel laterals are needed there.

ABUTMENTS.—As will be noted from Fig. 1, the lines of tracks of the railway under the bridge are on a skew angle with the line of bridge. At first it was thought advisable to build the entire bridge on a skew, but the awkwardness of the skew bracing for such a design caused the engineers to build a right angled crossing, skewing the back end of the abutments to the line of the tracks, the building lines and the nearby streets. The abutment as built is shown in Fig. 3. It consists of two separate walls, 8 ft. thick at the top, widening to 10 ft. lower down and extending to solid rock, some 30 ft. below the ground surface, where the bottom plane is jagged to resist horizontal movement. The floor system back of the hinge is carried on a 3 ft. wall joined at the extreme rear by a reinforced-concrete beam.

As is the practice in many of the Philadelphia bridges large size stones were embedded in the mass concrete of the abutment. Through this mass concrete an old sewer passes and proper provision had to be made during construction to preserve its continuity.

Highly ornamental cast-iron lamp posts and a zinc and cast-iron railing are provided. The web of this railing and the top and bottom rails are to be made of rolled zinc. The web is flat but ornamental with stamped or embossed figures and the rails are to be cylindrical, rolled from flat plates, and filled with concrete. They are then to be riveted to the web and the entire solid railing set up between galvanized steel posts and cast-iron newels.

LOADS AND STRESSES.—The concrete inside of the plate-girder arch ribs serves a triple purpose: it stiffens the ribs, takes a portion of the stress and protects the interior of the ribs from corrosion. Under no condition of loading does the pressure line in the arch rib leave the middle third of the ring and under the conditions of final loading this line will be very near the neutral axis. In consequence, the ribs will always be under compression. Now in so deep a steel arch ring any web must be heavily stiffened if the stress is to be distributed equally over the entire section. Usually such stiffening is made with exterior angle stiffeners and internal diaphragms, but in this bridge the concrete serves the purpose, resisting internal bending by its own mass and external bending by the rigidly held bolts through the webs and concrete. The construction is no doubt equally as effective as the older forms, and, according to estimates, cheaper in cost.

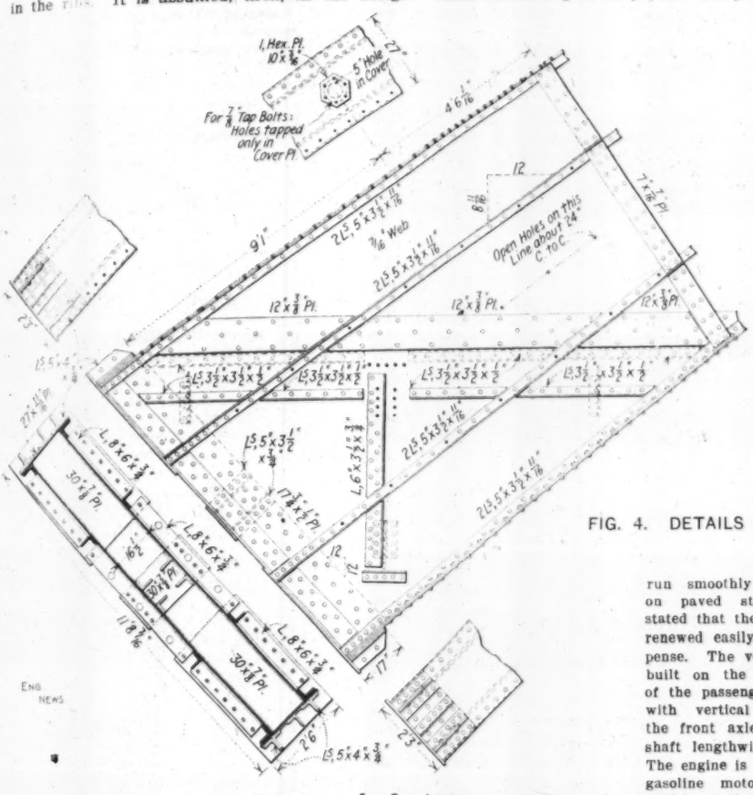
In addition the concrete is designed to take some of the load down the arch ring. The weight of the entire steel framework together with the

wet concrete filling in the arch will give the steel arch an initial stress about one-third of its designed maximum. After filling the ribs the concrete in them will be allowed to set before the floor concrete and paving is applied, so that these two latter items of dead load and the entire live load will be partially carried by the concrete in the ribs. It is assumed, then, in the design that the steel arch ribs take, uniformly distributed through their section, the entire dead load except the floor concrete and paving and that the remainder of the dead load and all of the live load are distributed between the steel ribs and the enclosed concrete, distributed proportional to their respective areas and moduli of elasticity. Thus at the crown, the total unit stress on the section under maximum load is about 2,400 lbs. per sq. in., of which one-third or 800 lbs. is due to the initial dead load and is taken entirely by the steel and 1,600 lbs. is taken by the combined steel and concrete. Assuming a ratio of moduli of elasticity of steel to concrete of 15 and a ratio of area of concrete to steel of 4.5 to 1, the unit stress on the concrete will be 488 lbs. per sq. in., and on the steel 4,000 initial and 8,000 total.

The maximum fiber stress in the steel at point of greatest eccentricity is about 12,000 lbs. per sq. in., if the concrete filling be disregarded, and the temperature stresses, with a range of 90° F., add about 3,000 lbs. to this so the maximum steel rib stress would be about 15,000 lbs. per sq. in., if there were no concrete filling. It is expected that the temperature changes in the arch rib will be much less than the 90° F. assumed on account of the additional protection afforded by the concrete.

The bridge is designed for a distributed load of 100 lbs. per sq. ft. and a concentrated load of 40 tons on a 4-wheeled car truck on the roadway and 110 lbs. per sq. ft. on the sidewalk.

The bridge was designed in the office and under the direction of Mr. Henry H. Quimby, M. Am. Soc. C. E., Engineer of Bridges, under the general supervision of Mr. George S. Webster, M. Am. Soc. C. E., Chief Engineer of the Bureau of Surveys of the city of Philadelphia. The entire contract was let to the Owego Bridge Co. for $76,950 and by them the substructure was let to Field, Barker & Underwood and the superstructure to McClintic, Marshall Construction Co.



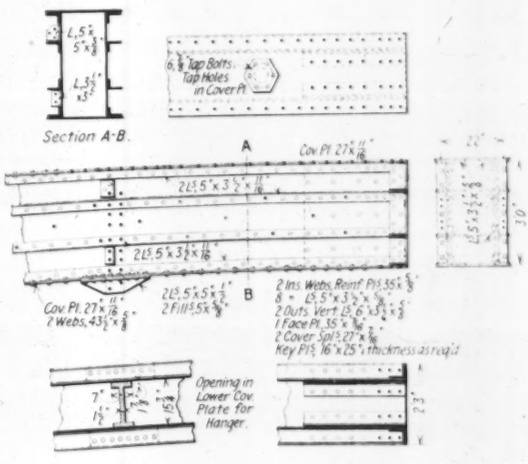


FIG. 4. DETAILS OF CROWN AND SPRING HINGES.

WOOD-INSERT WHEELS are used on the "Farm and City Tractor," a gasoline automobile intended for general hauling, recently designed by the Avery Company, of Peoria, Ill. The wheels have steel rims, perforated to receive round hardwood plugs or inserts 2 ins. in diameter and about 2 ins. long, set close together. The rear (driving) wheels have two rows of these plugs, the front wheels one row. The manufacturers expect these wheels to give many years' wear, and claim they run smoothly and silently on paved streets. It is stated that the plugs can be renewed easily at slight expense. The vehicle itself is built on the familiar lines of the passenger automobile, with vertical engine over the front axle set with its shaft lengthwise of the car. The engine is a four-cylinder gasoline motor. Its shaft sticks out of the front of the hood, so that a pulley can be attached for driving light machinery. The rear wheels are driven by two chains from a transverse countershaft. The entire vehicle weighs 4,600 lbs.; the makers say that it is able to "pull three or four 14-in. plows, pull a drag or scraper for smoothing roads, and haul loads on ordinary farm wagons and other vehicles behind it." The rear half of its length, moreover, forms a capacious platform for freight, and a box body can be set here. The price of the machine is given as $2,500.

GAS-ENGINE PUMPING STATION.—A contract for a new high-pressure, fire-service, gas-engine pumping station was closed in March by the city of Philadelphia. The new station will be located at Seventh and Lehigh Aves. in the Kensington Mill district, and will be practically a duplicate of the Delaware Ave. station, which has been in satisfactory operation for some five years. There will be ten 300-HP. Westinghouse vertical, single-acting, gas engines taking fuel from the city gas mains. Gas-engine units were selected because of the success of the Delaware Ave. station. It is claimed that the first year's operation of that plant (1904) was the most unfavorable one, but that in this year there was not a failure to start either in actual service or in the numerous trial runs. During this year there were 32 alarms and nine services, varying from a few minutes to 24 hours. During the year the large units ran 337 hours and the small units 198 hours, with a total of 27,000,000 gals. pumped. The average cost per thousand gallons was 12.5 cts. Any unit could be put upon the high-pressure line at 300 lbs. delivery pressure in 45 to 60 seconds, and the entire station could be put into service in seven to ten minutes. The compressed-air starting system has never given out, nor has the gas supply ever failed. The general contractor for the new station is the Millard Construction Co., and the detail engineering word is being handled by the Scofield Engineering Co.

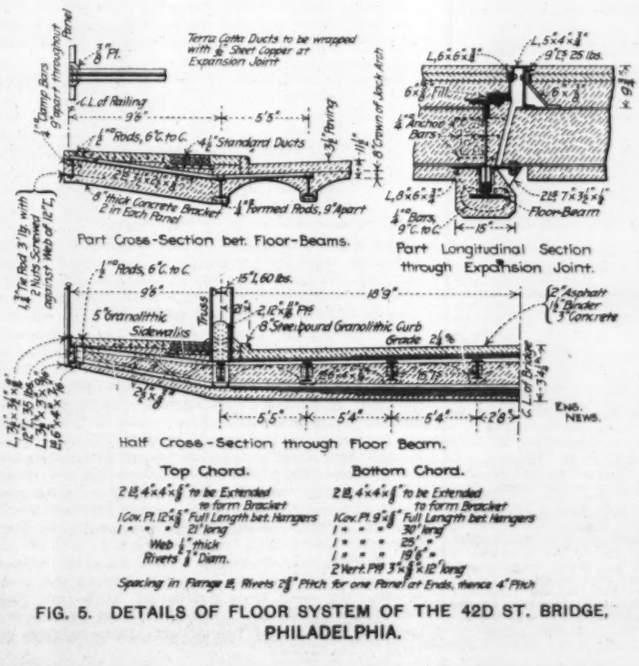

Part Cross-Section bet. Floor-Beams.
Part Longitudinal Section through Expansion Joint.
Half Cross-Section through Floor Beam.
Top Chord.
Bottom Chord.
Spacing in Flange B, Rivets 2½" Pitch for one Panel at Ends, thence 4" Pitch

FIG. 5. DETAILS OF FLOOR SYSTEM OF THE 42D ST. BRIDGE, PHILADELPHIA.

THE GROWING OF EASTERN HARDWOODS IN California is soon to be attempted by the U. S. Forest Service. An advance bulletin says:

The Service is planning to introduce a number of the more important eastern hardwoods into California, and will this year experiment with chestnut, hickory, basswood, red oak, and yellow poplar or tulip trees. Small patches of these trees will be planted near the forest rangers' cabins on the National Forests, and if those do well larger plantations on a commercial scale will soon be established on wider areas.

There are over 125 different species of trees in California, a number of which produce some of the most valuable varieties of lumber in the country. Although considerably over one-half of the species are hardwood or broad-leaved trees yet, with the exception of the exotic eucalyptus, there is not a single species of hardwood here ranking in commercial importance with the leading eastern hardwoods. Climatic conditions in many parts of California are undoubtedly favorable for the growth of a number of the valuable hardwoods, and the absence of these trees is due mostly to unfavorable factors of seed distribution. If the experiments are successful, a valuable asset will have been added to the forest resources of this State, which should prove of special benefit to the local furniture and vehicle industries. Chestnut and red oak are highly esteemed for furniture, while with hickory, basswood, and eucalyptus at its command, California should lead all other states in the vehicle industry.

Screw Spikes and Improvements in Rail Fastenings.

The subject of improved fastenings for attaching rails to ties in track construction seems likely to receive more attention in the future, owing to its important relation to the economies which may be attained by the use of treated ties. The necessity for such an improvement was pointed out at the recent annual meeting of the American Railway Engineering and Maintenance of Way Association. In a bulletin issued by this association, there is an interesting paper on the use of screw spikes, by Mr. W. C. Cushing, M. Am. Soc. C. E., Chief Engineer of Maintenance-of-Way of the Pennsylvania Lines (Southwest System). Accompanying this are several articles taken from European technical papers dealing with different phases of the subject. We give herewith an abstract of Mr. Cushing's paper, and some of the appendices, and in our editorial columns we have discussed some of the leading features of the subject.

The Use of Screw Spikes.*

Apparently the French railways were about the first in Europe to begin the use of the screw spike as a rail fastening, and it is to-day universally employed by the large systems. Its development began in about 1860. Mr. Jules Michel, an earnest student of maintenance-of-way

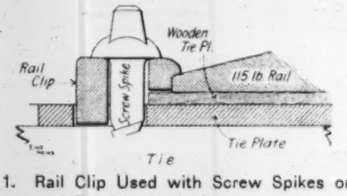


Fig. 1. Rail Clip Used with Screw Spikes on the Belgian State Railways.

questions, has related the results of the long study of the screw fastening which he and others made for the Paris, Lyons & Mediterranean Ry.† The German railways did not adopt this style of fastening as early or as generally as those of France, and Mr. Siegler points out in his letter (accompanying this article) that the use of the hook-spike is quite widespread. In 1899, the general employment of the screw-spike on all lines of the system was prescribed for the Prussian Government Railways.

The common hook-spike at present in universal use in the United States has been often severely condemned, and readers have been usually led to infer that the screw-spike is employed everywhere in Europe, which is not the case. Indeed, the screw-spike in Great Britain is almost as rare as it is in the United States, at least on the large systems, the only one making use of it being the London & Northwestern Ry., and that only partially.‡

Mr. Michel (already referred to) has given the resistances to extraction of different kinds of screw-spikes in different species of woods, and this information has been several times supplemented in this country. It is now well known that the forces required to pull screw-spikes from ties are conservatively from 1½ to 2½ times greater than those required to pull hook-spikes.

The Paris, Lyons & Mediterranean Ry. experiments also covered an investigation of the pitch of the thread, its form (that is, whether a cross-section should show an isosceles or a right-angled triangle or a form intermediate between the two), and the diameter of the shank. It appears that the tests did not indicate any superiority of one form of thread over the other, the right-angled or the isosceles. From the results of the experiments, the dimensions of the screw-spike were fixed as follows:

Pitch of thread	0.49-in.
Projection of thread from shank	0.12-in.
Base of thread divided by perpendicular from apex into two parts, respectively	0.10 and 0.06-in.
Diameter of shank	0.55-in.
Diameter under cap	0.79-in.

The principle laid down for calculation was that the length, the diameter of the shank, and the depth of threads should be calculated respectively to offer a resistance to pulling out, considering the nature of the ties, nearly equivalent to the resistance to rupture of the shank of the screw-spike. These dimensions have been practically adhered to up to the present time.

A recent study by Mr. E. Perroud, Engineer of Track of the Northern Railway of France, on the facility of insertion of screw-spikes, was sent to the writer by Mr. Rossignol, Chief Engineer of Maintenance of that railway. In addition to the notes on the descent of the screw, the author also discusses the effect of successive insertions of the same screw in the same hole, which illustrates how repeated tightening will impair the value of the screw fastening. This is a hint that the screw is not a perfect fastening, and indeed we frequently notice reference to the two considerable defects which somewhat impair its usefulness; the tendency to work loose, and the final enlargement of the hole, which has made it necessary to devise some means for making repairs, in order to make the life of the tie from mechanical wear equal to that given to it by antiseptic fluids. In the case of softwood ties the question is of vital importance. Mr. Cuënot has discussed this in his book on "Track Deformations," and Mr. Cartault, Chief Engineer of Maintenance of Way of the Paris, Lyons & Mediterranean Ry., wrote a paper on the subject, which was published in the "Revue Générale des Chemins de Fer" for February, 1900.

The latter stated that his company had a great number of softwood ties in use in its tracks which gave insufficient resistance, especially on curves, and the defect was very difficult to remedy till Mr. Albert Collet invented the hardwood screw trenail about 12 years ago. He stated that the results from practical tests during more than four years have given full confirmation to the theoretical expectations he had on its first appearance. The tests showed that with the Collet trenail in pine ties the resistance of the screw to extraction was increased by 29%, and in Baltic fir by 39%. In the case of old ties eight years in service, the increased resistance given by the trenail was 80% in pine, 33% in beech, and 62% in oak.

Nevertheless this company has at the present time abandoned the use of soft woods for ties, and only considers hard woods (oak and beech) as its standard. The use of trenails is confined to the repair of holes in old ties, and their use is inconsiderable in such woods as oak and beech.

The main objection to the Collet trenail is its size, being 1¾ ins. diameter outside the threads. This cuts away a considerable portion of the critical part of a tie, and is considered by many engineers to weaken the tie too much. The tie plug is only about 1 in. square. Nevertheless this screw dowel is largely used in Germany.

The Collet trenail has been tested from the beginning by the Chemin Eastern Ry., of France, but the square plug is preferred. The wooden screw, often made of elm, cannot be put in place without removing the tie from the track, and it frequently splits. Mr. Siegler, in his letter, states that the ties on this road are principally oak and beech, while Mr. Cartault says the Paris, Lyons & Mediterranean Ry. had a great many softwood ties, which evidently accounted for the more favorable reception in the beginning of the Collet screw dowel on the latter. But the latter has now also given up softwood ties.

The Thiollier steel helical lining is being experimented with as a substitute for the Collet trenail, and the Lakhovsky screw and steel casing (for spreading in the hole in the tie) are considered worth trying by the Eastern Ry. and the Paris & Orleans Ry.

Another partial remedy is the removal of the screws from the office of holding the base of the rail to that of holding down a large heavy cast-iron base plate, approaching in size that of the chair in use on English railways. This brings in the subject of tie-plates, which it is not the writer's intention to discuss, although it is difficult to separate the questions of screw-spikes and tie plates in the case of ties treated with an antiseptic fluid.

The screw-spikes used by the French railways are closely similar, although they differ somewhat in detail. There are three sizes, referring to the diameter of the neck under the cap, 0.79-in., 0.87-in. and 0.91-in., the latter predominating. The diameter of shank for these sizes is 0.55-in., 0.59-in., and 0.65 to 0.67-in., respectively. The pitch of thread is generally 0.49-in., although there is one 0.39-in. and one 0.31-in. The projection of the thread from the stem is 0.12-in., but its cross-section varies slightly. The length, of course, varies with the thickness of tie and other fastening details, while the diameter of cap runs from 1.38 to 2.05 ins. The head for the socket of the wrench is from 0.79 to 0.91-in. square. Two of the systems use two of these screws inside and two outside at each rail; three use two inside and one outside (one of them in some cases using one inside and one outside); while another has two inside and one outside, alternating with two outside and one inside.

In Belgium the screw-spike differs somewhat in the shape of thread from the foregoing, although the pitch is about the same, being 0.47-in. for 105-lb. rail, and 0.38-in for 115-lb. rail. The diameter of neck is respectively 0.95-in. and 1.18-in. An interesting form of clip to be used with this screw-spike [illegible] 115-lb. rails is shown in Fig. 1.*

Screw spikes which are of a general [illegible] similar form are used by several government railways [illegible] Germany. The diameter of the neck under the cap [illegible] 79-in., and of the shank 0.59-in. The pitch of the [illegible] is 0.26-in. and its projection from the stem 0.10-in. [illegible] nese dimensions are slightly less than the French [illegible] ilways use. All of the lines use the Haarmann ho[illegible] plate, but some place the hook on the inside and [illegible] on the outside flange of the rail. In the former [illegible] two screw-spikes are used inside and outside at each [illegible] rail, in the latter case this order is reversed. Only [illegible] road confines itself to one screw inside and one [illegible] side. The various designs of clips usually provide [illegible] adjustment in the gage, which in some cases is carried to extreme refinement. A novel design for solving [illegible] joint problem is used by the Prussian government railways in their latest standard for track; the two joint ties are in contact and fastened together.

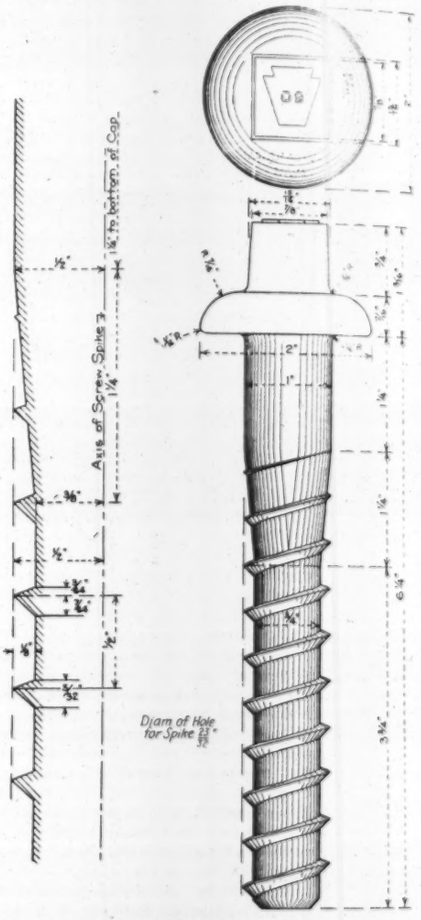


Fig. 2. Suggested Design of Screw Spike for American Railway Track (Derived from French Practice).

All of the large railway systems in Great Britain use the double-head rail, held in position in large cast-iron chairs by wedges. Consequently the fastenings are for securing the chairs to the ties. The almost universal plan is to use two (round) iron or steel spikes and two wooden trenails. The spikes are not pointed, and are driven into previously bored holes. Instead of the trenails, the London & Northwestern Ry. makes use of two screw-spikes.

The proof that the screw-spike is not a thoroughly efficient rail fastening lies in the devices which have been invented to assist it in its work, the square plug, the Collet trenail, the Thiollier helical lining, and the Lakhovsky split-wedge case. Furthermore it will be found to be a nuisance in the case of a derailment or wreck which has torn up the track, and when broken off it must be replaced by another in a new hole outside the tie plate. Nevertheless, from its greater holding power,

*By W. C. Cushing, M. Am. Soc. C. E. From a bulletin of the American Railway Engineering and Maintenance of Way Association, 962 Monadnock Block, Chicago.

†Forestry Bulletin No. 50; U. S. Department of Agriculture, Washington, D. C.

‡In England, however, the rails are of double-head section, carried in large and ponderous cast-iron chairs which are secured to the ties by round iron spikes, wooden trenails or screw spikes. The conditions in regard to fastening these chairs to the ties are somewhat different from those where tee-rails rest directly upon the ties (or with a tie-plate interposed) and are attached directly to the ties.—Ed.

*In a majority of cases, the mushroom head of the screw spike bears directly upon the base of the rail, but clips are used on many railways. It has been recommended that where clips are not used, there should be steel tie-plates having ribs or shoulders so that the spike head will be supported on the outer side instead of having only its inner side supported by a bearing on the rail base.—Ed.

the verdict of the engineers of the French, Belgian and German railways is that it is superior to the hook-spike, because they consider it very important to hold the rail fast to the tie.

It would simplify matters to use bolts passing entirely through the tie, as the Great Western Ry. has done in England. This might not be objectionable if it were not necessary to renew the bolts, which would require the temporary removal of the tie. Even though the bolts do not break, they would surely have to be renewed during the period of 18 to 25 years which the ties last, for we now find it necessary to renew splice bolts in much less time.

If the use of the screw-spike is to become general in the United States, the design to be deduced from European practice is, as shown in Fig. 2, with dimensions about as follows:

	Ins
Diameter of neck under cap	1
Diameter of shank or stem	3/4
Pitch of threads	1/2
Projection of threads from stem	1/8
Length of base of thread in section	5/32
Base of thread divided into two parts { Upper part.	3/64
by perpendicular from apex { Lower part.	7/64
Diameter of cap	2
Thickness of cap	7/16
Base of head (square)	15/16
Top of head (square)	7/8
Length of head	3/4
Diameter of hole required for this screw	29/32

Screw Spikes on French Railways.*

The Eastern Railway, of France, has not been using common spikes for more than 30 years, and this is the case with all the large French railways which employ tee rails. In the rest of Europe the use of the spike is still quite widespread. Some years ago the Germans and notably the Austrians held that the spike is preferable. Then they began to give preference to the screw-spike for the interior of the track, while preserving the common spike for the exterior. But the common spike is progressively tending to disappear.

In our opinion the screw-spike is of unquestionable superiority, on the condition that it be properly used. The experiments which caused the Germans to believe that the screw-spike is inferior to the common spike were badly made, and a badly made experiment is worse than no experiment at all. In order to have good results, there are necessary: (1) A good screw-spike; (2) its proper use.

It is necessary that the spiral threads of the screw-spikes be placed so as not to damage the fibers of the wood too much, that is to say, be not too close together. In our screw-spike the pitch of the thread which was formerly 0.287-in., has been enlarged to 0.49-in.; we are satisfied with it. It is necessary that the neck of the screw-spike (that is to say, the upper part under the cap) be not too thin, in order not to bend under the force which is produced from only one side. The head ought to bear a letter or a figure in relief, so that the workmen cannot strike on the head with the hammer, in order to sink it in the wood, without detection resulting from the crushing of the letter.

The length of the screw-spike ought to be such that it does not penetrate the bottom of the tie. The diameter naturally varies according to the resistance to be given to the track. We have screw-spikes of 0.75-in. diameter, but we now use scarcely any others than those of 0.91-in. This diameter may also depend on the number of screw-spikes which are placed in the same tie, for when three screw-spikes are placed in each end of the tie too much wood is removed and the tie is weakened too much if a diameter of more than 0.91-in. is adopted.

Formerly our screw-spikes were of iron; to-day they are of soft steel. It would be desirable to use harder steel in order to make the screw-spikes more resistant to flexure, but then the manufacture would become more difficult.

Our 91-lb. rail rests on the tie without metal tie-plates, except on very sharp curves (of 984.25 ft. radius and under). We place under the rail, solely to protect the wood against the mechanical action of the base, plates of poplar or felt. These plates are compressed before being used, so that they will not be further compressed under the pressure of the rail.†

In order to put in the screw-spike, a hole is bored in the tie with an auger of 0.48-in. diameter for the screw-spike of 0.75-in., and an auger of 0.65-in. diameter for that of 0.91-in. The screw-spike, previously tarred, is screwed in with a key whose arms should not be longer than 25.6 ins., in order that the workmen may not be able to exert an excessive force and tear the wood. One man is sufficient to put in the screw-spike except for the final tightening, when a second man is useful. In order to do this work a man ought always to place himself so that the rail is between him and the screw-spike to insure its being put in straight.

We are commencing, in France, to use electrical apparatus for screwing and unscrewing screw-spikes (and others for tamping the ties). With this apparatus it is necessary that there be an arrangement for making it impossible for the force exercised on the screw-spike to exceed a certain maximum.

Our ties are, with rare exceptions, almost all of oak and beech. I estimate that the soft woods (pine and fir) are not suitable for the tee rail track, and that when one cannot get any other wood it is much better to adopt the track with double-head rail. The force of extraction which one of our screw-spikes in a new tie can resist is 12,125 lbs.

In time, the sides of the hole bored in wood may be spoiled; I could show you, however, tracks 20 years old over which 80 trains a day are passing and where the screw-spikes still hold as in the beginning; the beech holds better than the oak.

In order to stop the creeping of the rail, the splice bar butts against a screw-spike of special form having a shoulder head. We also employ stop checks (anti-creepers) fixed on the rail near its middle by means of a bolt and on the tie by means of ordinary screw-spikes.

When the hole is injured by excessive force or by a split in the tie the screw-spike no longer holds; it turns easily. Then the hole is repaired by driving in a square or rectangular tarred plug and by boring holes in the plugs. The plug is 0.91 × 1.06 ins., and 4.5 ins. long.

Old holes can also be repaired in different ways: (1) The trenails, invented by Mr. Collet, are used by the Paris, Lyons & Mediterranean Ry. and their use is quite extensive in Germany. They are plugs of hardwood tapped on the outside; they are screwed in the hole of the tie previously enlarged, and afterwards the screw-spike is screwed in it. They have given good results, but require larger holes which weaken the tie. (2) With Thiollier's lining, a steel spiral is screwed into the hole. The results are satisfactory up to the present time. But, in general, we are contented with square plugs, and when the track is well maintained, the repairs of holes are the exception. We are trying finally the Lakhovsky system, which it seems ought to succeed. The wooden tie-plates (noted above) are of poplar. When they should be compressed before using we have them furnished 0.20-in. thick, and the compression brings them to 0.16-in. The notch made in the tie being 0.35-in. deep, there remains 0.20-in. of wood for the lateral support of the base.

We only employ metal tie plates exceptionally, on curves of short radius; the Paris, Lyons & Mediterranean Ry. uses them on all the ties. The plates have the advantage of making the two screw-spikes act together; that is to say, the outside screw-spike cannot be pushed out by the base of the rail without drawing after it the inside screw-spike.

But they have, in my opinion, the following disadvantages: (1) They cut the base of the rail; (2) they rattle when they are not well maintained; (3) the threads of the screw-spike wear off in the holes of the plates when the latter are not too large; (4) when a hole for a screw-spike is injured it is not easy to repair it and another hole cannot be bored without displacing the plate. Nevertheless, the Thiollier spirals permit the repairs to be made quite conveniently.

The screw-spikes can be rendered more stable in the transverse direction by having them supported, not directly on the base of the rail, but on clamps which are placed directly on the tie or on a metallic plate. The Germans employ systems of this kind. We have not recognized the utility of complications of this kind, except in the case of very sharp curves, 820½ ft. radius and under. We avoid unnecessarily multiplying the number of pieces constituting the track.

If our screw-spikes can be found fault with for anything, it is perhaps that they hold too well. With your spikes, which do not press hard against the rail, the latter lifts a little without dragging the tie immediately with it, the latter remaining in the ballast. On the contrary, our tie lifts with the rail. But this disadvantage (if it is one) could be easily remedied by loosening the screw-spike a little after having screwed it home.

Chair Supports for Tee Rails on German Railways.*

During the last 12 years a satisfactory fastening between rails and soft wood ties has been a subject of continuous experiments on the Prussian government railways. The first investigations followed the general use of rolled steel tie-plates, 7⅛ × 6¼ ins. It was soon discovered that on soft wood ties, the small adhesion between the spike and the wood permitted the spikes to pull out more or less, and the loose rail, under the sudden applications of load, would quickly batter down the wood.†

Some improvement was obtained by the use of screw-spikes, without, however, entirely overcoming the abnormal wear, and the consequent looseness and ineffi-

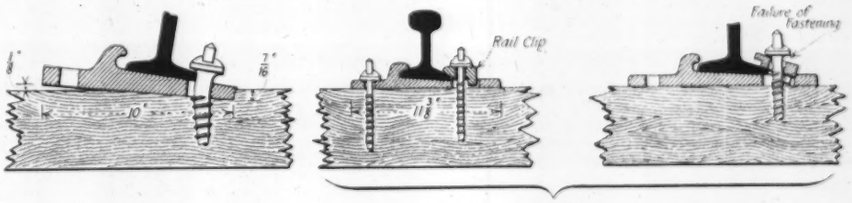


Fig. 3. Fig. 4.

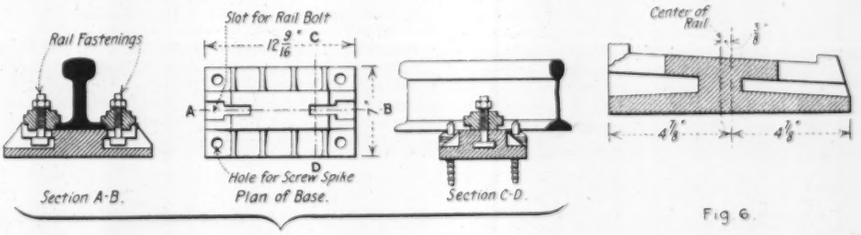


Fig. 5. Fig. 6.

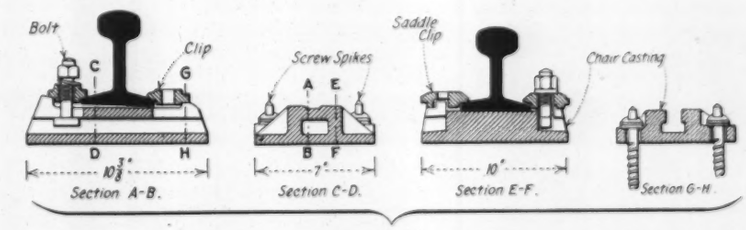


Fig. 7.

FIGS. 3 TO 7. DEVELOPMENT OF CHAIR CASTINGS FOR THE SUPPORT OF TEE RAILS; PRUSSIAN STATE RAILWAYS.

*By Mr. E. Siegler, Chief Engineer of Track, Eastern Railway of France. This is the letter (slightly condensed) mentioned in the preceding paper by Mr. Cushing.

*Abstract of a translation from the "Organ für die Fortschritte des Eisenbahnwesens," printed in a bulletin of the American Railway Engineering and Maintenance of Way Association as an appendix to the paper on Screw Spikes by Mr. W. C. Cushing.

†The tie-plates used by European railways are usually much thicker and heavier than those used in this country, and have no ribs or flanges to give them a hold in the wood of the tie. Thus they depend entirely upon the rail fastenings for their attachment to the tie, and if the fastenings are loose the plates can shift and rattle.—Ed.

this supposed defect, rail clips were introduced, giving the head of spikes a full support all around, Fig. 4. This arrangement proved to be much better than any previous one, but still did not produce a satisfactory fastening. The cut indicates clearly the manner of failure of these plates.

It is evident that the plate-hook, being rigid and incapable of producing any actual pressure against the rail flange, would cause all the stresses to be carried against the screw fastening, and as soon as this would wear in any of its parts, the rail would become loose under the hook, and the shocks would begin their destructive work. Also, the direct pressure under the head of the spikes would tend to pull these out of the tie, and constitute another element of weakness to the general construction.

With every one of the devices tested, while the fastening was rigid and doing all the work it was intended it should do, no great strain was apparent at the joint ties, where the joint material was fastened to these; and no tendency was apparent in the track to creep longitudinally. But as soon as the fastenings became loose, the creeping tendency reappeared, and, being resisted only at joint ties, would soon damage the fastening of these and cause general deterioration at these points. This leads to the conclusion that if every tie is rigidly fastened to the rail, longitudinal movement of the track is practically overcome, and deterioration of joint fastenings or joint ties will be prevented.

The impossibility of fastening the rail with the same amount of holding power on both sides, besides the drawbacks enumerated above, led to the introduction of an entirely different system of fastening. As a result of the investigation related, the following experiments with cast-iron plates were made:*

The first style of plate is shown in Fig. 5. These plates had a bearing on the ties of 90 sq. ins., as against 80 sq. ins. in the largest previous plate, and were fastened to the ties by four screw-spikes absolutely independent of the rail fastening. The rail was in its turn fastened to the plate by means of two bolts and clips, these being independent of the tie fastening.

The clips were made so as to be capable of adjusting the gage of track by being reversible, and also of such a shape as to take up and transmit horizontal forces at base of rail to the shoulders provided in the plates. In this manner the upward forces would be resisted by all the screw-spikes, and similarly all horizontal forces would be taken care of. Spring washers were provided under the heads of screw-spikes and the rail fastening nuts.

In 1898, 88 of these plates were put in service; these were removed from the tracks (together with the ties) in 1907, for the purpose of examination. The tie wear was found to be very slight and very uniform under the base of plate, varying from a minimum of 1-128-in. to a maximum of 1-100-in., except in a few cases where spikes had become loose and caused an increase as well as an irregular wear. Sand, however, was found between the ties and plates, and this might have caused even this slight wear. The rail seat in tie plate had worn to about the same extent. No other sign of deterioration was observed.

The main difference between these plates and the plates of the second group I lies in the size of the bearing surface on the tie, being about 70 sq. ins., as against 90 sq. ins. for those of the first group. On removal of plates, it was found that the tie developed the same uniform wear as in the previous group. The slight wear gave the impression of being purely compression, there being no indication whatever of side displacement. As a matter of fact, after the screw-spikes had been removed the plate had to be knocked off with a hammer. Sand was found under the edge of only a few plates. The screw-spikes used on these plates were 4¾ × ⅝-in. and had a deeper thread than those of the first group.

In spite of the smaller bearing of this plate, the amount of tie wear was actually smaller, and the fastening generally more satisfactory.

The main difference in the plates of the third group consisted in the sloped top of the plate, which gave the rail a desired amount of inclination toward the gage side. This arrangement brought the center of rail closer to the outer edge of the plate by about 5/16-in. (Fig. 6). The screw-spikes were similar to those in the second group, but with a somewhat better grip, the holes having been drilled smaller. To increase the rigidity of the fastening, double spring washers were employed on all the screw-spikes.

The tie wear was smaller than in any previous instance. The gage of track was measured frequently and found to remain practically unchanged. The spring washers, which had shown some failures when used singly, were found in this test to have their original elasticity unimpaired. This design of plate, however, failed in few instances as shown at (A) Fig. 6, which would seem to indicate that a greater stress was carried against this point than in the other arrangements.

CONCLUSIONS.—It is clearly evident from the behavior of the plates that the wear of the ties is not at all directly proportional to the extent of the bearing surface of the plate, but depends more on the rigidity of the fastenings. This rigidity was obtained in the second and third groups by the use of screw-spikes with deep thread, by drilling the screw holes of small diameter, and by the use of double spring washers under each screw, capable of producing a combined pressure of about 140 lbs. A single spring washer, capable of developing an equal amount of pressure, would probably answer as well, and it (or its equivalent) should be used, especially at curves.

Another important fact brought out was that to have a successful fastening, all the component parts of the arrangement should wear uniformly.

The cost of maintenance increases rapidly through the successive removal of single parts, and, as a general rule, wornout or defective component parts of any structure increase the work done by other parts, and eventually some of these fail in service which would have been sufficient for doing their normal share of work. In the case under consideration, the most important point developed is the necessity of rigidly fastening the rail to the ties in order to preserve the life of these and to obtain a satisfactory track structure.

Experiments are still under way with a view of ascertaining the least size of a satisfactory plate provided with a firm and rigid fastening. Other special forms are also being investigated, as shown in Fig. 7.

*These plates or chairs, it will be seen, are a radical departure from the ordinary tie-plate or base-plate. The chairs for the double-head European rails extend above the base and provide a lateral support to the web. This arrangement has been adapted to chairs for tee rails in Italy.—Ed.

Reinforced-Concrete Trestles with Pile Bents and Girder-Slab Spans: Chicago, Burlington & Quincy Ry.

Reinforced-concrete trestles with pile bents represent a decidedly novel type of railway structure, designed to supersede timber trestles of medium height crossing low ground, where the conditions are not favorable for the use of a solid bank with culverts for drainage. Several such trestles are now being built on the lines of the Chicago, Burlington & Quincy Ry. to replace old wooden trestles. Structures of this type, but of monolithic construction, have been built by other railways, but the special feature in the design adopted by this railway is the use of concrete piles and concrete floor slabs or girders, so that the work of erection is very similar to that for a timber trestle. The general type of construction is shown by the view Fig. 1 and the cross-section, Fig. 2.

FIG. 1. PILE TRESTLE BUILT ENTIRELY OF CONCRETE; CHICAGO, BURLINGTON & QUINCY RY.
C. H. Cartlidge, M. Am. Soc. C. E., Bridge Engineer.

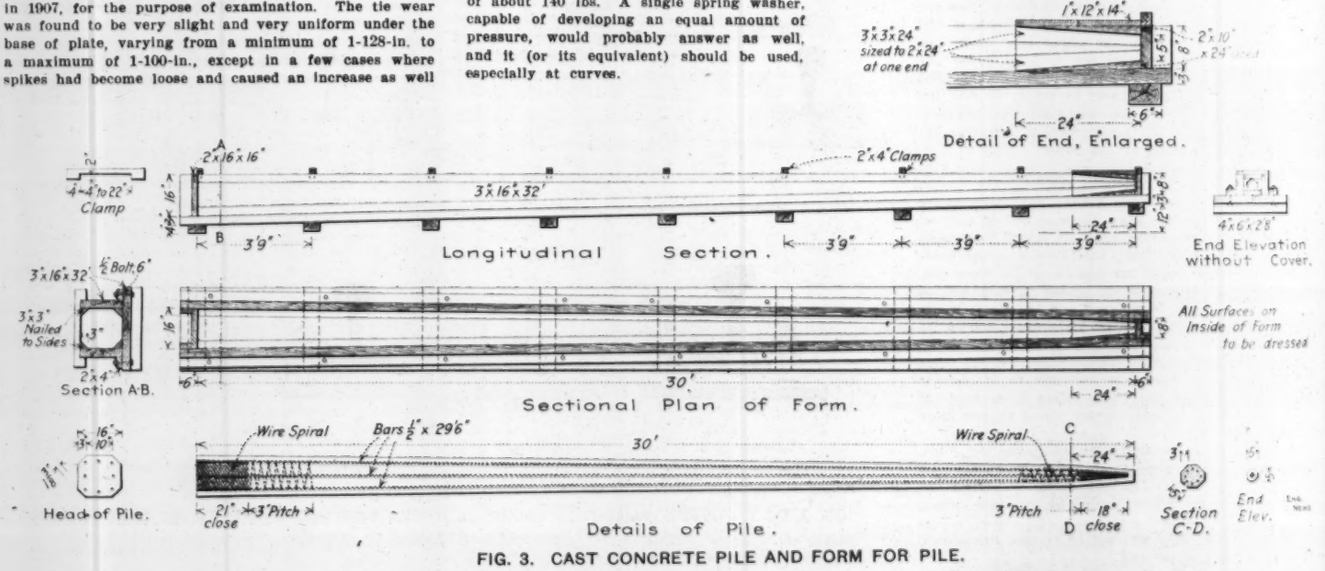


FIG. 3. CAST CONCRETE PILE AND FORM FOR PILE.

The spans are 14, 15 or 16 ft. long, c. to c. of bents. Each bent consists of six concrete piles handled and driven in the same way as timber piles, supporting a cap or cross girder which is cast in place. Upon the caps rest the girder slabs which form the floor, each span consisting of two slabs placed side by side.

The concrete piles are of two forms: (1) rectangular cast piles; (2) Chenoweth rolled piles. The cast or molded rectangular piles are made to the designs of the Bridge Department. They are made in lengths up to 30 ft., and most of them are not pointed, being 8 × 8 ins. at the

smaller end. The general design of the pile (but with a point tapering to 5 x 5 ins.) is shown in Fig. 3, and this also shows the construction of the form. The 30-ft. piles are 16 ins. square at the top, with 4-in. chamfers. The reinforcement consists of eight ½-in. bars and a spiral coil of wire of varying pitch. The wire is coiled on a mandrel, as shown in Fig. 4; when the coil

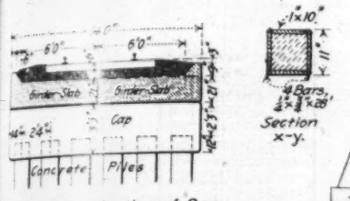


Fig. 2. Cross-Section of Concrete Pile Trestle.

is completed, it is removed and set in place in the form, the longitudinal rods being wired to it at intervals. Each 30-ft. pile contains: 1.044 cu. yds. of concrete, eight steel bars ½-in. square and 29 ft. 6 ins. long, and 535 ft. of No. 12 black wire.

Experiments are being made with a rectangular pile in which a feature of the reinforcement consists in the use of a sheet of wire netting folded into the form of a rectangular box somewhat smaller in section than the section of the pile, the ends being lapped on one side. Longitudinal bars are wired to this box. This arrangement is much simpler than the use of a spiral coil, but none of the piles have been used as yet in actual construction.

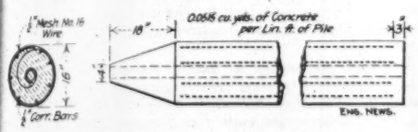


Fig. 5. Rolled Concrete Pile (Chenoweth System).

The Chenoweth rolled concrete pile (Engineering News, July 26, 1906), has a reinforcement consisting of a spiral sheet of netting, with the usual longitudinal bars. This is shown in Fig. 5, and has 0.0515 cu. yd. of concrete per lin. ft. of pile. For making these piles a special plant is used, as shown in Fig. 6. A sheet of wire netting the full length of the pile is laid upon a table which has a traversing motion and is operated by machinery. One edge of the sheet of netting is attached to a slot in a 3-in. solid shaft, while the other edge is secured to the table. At intervals are the longitudinal reinforcing bars wired to the netting; they are raised slightly above the netting to allow of packing concrete between them.

The ends of the central shaft are connected to spindles carried in fixed frames at each end of the table. A layer of concrete is spread upon the netting and dressed by templates to a desired contour. By means of gearing the central shaft is then revolved, while at the same time the table is traversed under the revolving shaft. In this way the netting is wound up with the concrete as shown in Fig. 5.

When the rolling is completed, the pile is given a few revolutions under pressure from rollers carried in the frame, which thus compact and compress it. At the same time, and while making these revolutions, the pile is wrapped with wire from spools placed beneath the table, and when the pile is finished and wrapped, these wires are cut and tied. The wires are spaced from 2 ins. to 4 ins. apart for the lower portion of the pile and 6 ins. apart for the remainder of this length. The central shaft is withdrawn, and the pile is then rolled from the table onto a narrow car which carries it to a platform where sheet iron forms for the head and point are attached. This platform is seen at the left of the frame in Fig. 6; at the right is the concrete mixing platform. The point is bonded to the body of the pile by the projecting end of the spiral coil of netting. The pile is left for a few days, and then taken to the storage yard, where it remains for about 30 days, the piles in the yard being sprayed with water every day.

Tests of some of the Chenoweth piles have been made at the Engineering Experiment Station of the University of Illinois under the direction of Prof. A. N. Talbot, M. Am. Soc. C. E., who has kindly furnished us with some general particulars of the results obtained thus far. These give an idea of the quality and uniformity of the concrete. Full information as to the tests and their results will be given after the completion of the full series of tests. The piles tested were approximately 14½ ins. diameter and 3½ months old. Failure occurred generally at the ends, and not in the body of the pile. The ultimate pressures ranged from 257,000 lbs. to 356,000 lbs. This last pile was originally 20 ft. 3 ins. long, and failed (at one end) at 270,000 lbs.; it was then cut to 17 ft. 3 ins. and tested to failure (at the other end) at 319,000 lbs. It was then cut to 14 ft. 3 ins. and failed at 356,000 lbs., as stated, again failing at an end. In these tests there was no sign of failure due to bending of the column, and a pile 24 ft. long failed in the same way as the shorter ones. The end failures were due in part to the less perfect concrete which the rolling gives at the ends, and in part to the imperfect bearing available for the testing machine.

In the construction of the trestle, the piles (whether of the cast or rolled patterns) are driven by a railway pile driver in the usual way. In most cases a drop hammer has been used, but it is intended to use a steam pile hammer on future work. A cushioned cap is used in driving, and there has been very little trouble from breakage of the piles. When breakage has occurred, it has been due, as a rule, to using a pile which has not been given sufficient time for thorough setting or seasoning of the concrete. The cost of driving is found to be a little higher for concrete piles than for wooden piles. Where possible, a water jet has been used, making the driving of the pile very much easier and more economical. The piles being driven, a form is built for the cap of each bent. This has a sheet-iron lining. The corners are chamfered and the ends of the caps are rounded. The concrete is well-spaded at the sides of the form to give a smooth surface. The construction of the caps is shown in Fig. 7. The forms are left in place about 30 days, before the superstructure is set in place.

Each span consists of two reinforced concrete slabs or girders, each slab forming half the width of the floor and having a curb wall to retain the ballast. Drain holes are cored in the slabs, and steel stirrups are embedded in them with the loops projecting so as to give a direct attachment for chains in handling. The general design of these slabs is shown in Fig. 8. Girder slabs of somewhat similar design (and based upon the track elevation work of this railway) have been manufactured by the Illinois Central Ry. for track elevation bridges in Chicago, the self-supporting concrete slabs covered with ballast, making a practically noiseless structure over the street. These bridges were described and illustrated in our issue of Aug. 6, 1908.

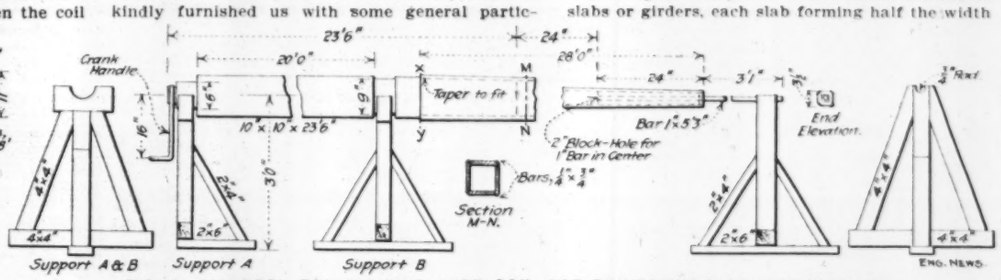


FIG. 4. MANDREL FOR WINDING WIRE COIL FOR REINFORCING CONCRETE PILES.

The concrete used for the trestles is of different composition for different parts of the work. For the piles is used a 1:3 mixture of cement and fine screened gravel, or a 1:2:3 mixture using sand and fine stone screenings. The concrete for the Chenoweth piles is made comparatively dry, while that for the cast piles is made very wet. For the caps and girders, the mixture is as follows: 1:4½ with gravel (pit or screened gravel, according to service); 1:2:4 with sand and stone. A 2-in. size is the maximum for both stone and gravel. The concrete is well spaded at the sides of the forms in order to give a smooth surface. The quantities and weights are about as follows:

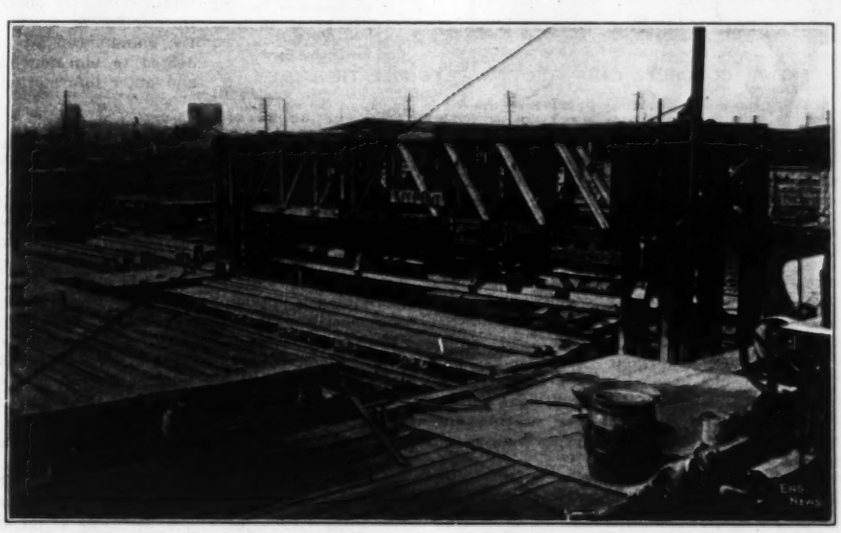


FIG. 6. MACHINE FOR MAKING THE CHENOWETH ROLLED PILES.

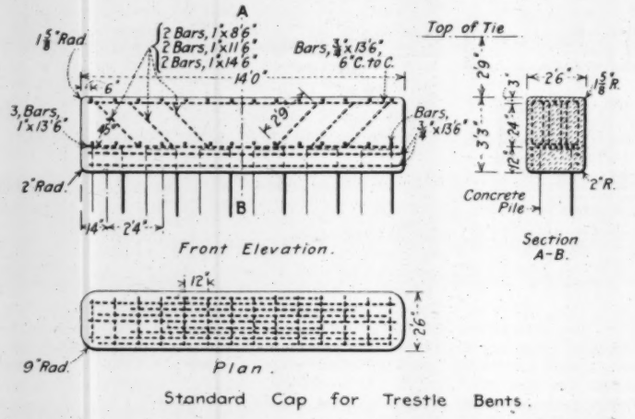
	Concrete, cu. yds.	Steel bars, lbs.	Weight, lbs.
Single cap	4.2	712	17,500
Double cap	8.5	1,320	35,300
Girder slab,* 14-ft. span	13.6	1,421	27,200
Girder slab,* 16-ft. span	16.8	1,815	33,600

*Each slab forms half the width of one span.

The cast piles and the girders were made by the railway company at its yards at Hannibal, Mo. The piles are allowed to season for about 30 days; the girders are allowed to season for 60 days before handling. The caps are cast in place, as already described, and are allowed to

season for 30 days before the girders are placed upon them.

For structures of over five or six spans in length, longitudinal rigidity is obtained by the use of double bents at suitable intervals. The double-bent consists of two rows of piles carrying a single cap of twice the usual width (Fig. 7). In the Salt River trestle (which was the first of these structures) a solid pier was used in place of the piles and cap at every sixth bent, but the double-bent construction is considered preferable. Where longer spans are used (about 25 ft.), and where the trestles cross streams in which floating ice has to be resisted, thin piers are used in preference to the pile bents. These are carried down to footings on a solid foundation, or may be supported by wooden or concrete foundation piles.



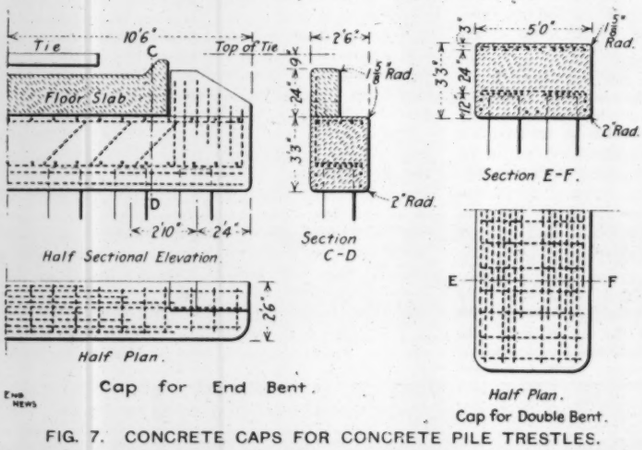


FIG. 7. CONCRETE CAPS FOR CONCRETE PILE TRESTLES.

(At the top is the standard cap; below on the left is the cap of the end bents, with curb wall; on the right is the enlarged cap for brace bents with two rows of piles.)

Provision for the protection of derailed cars is made by laying inside guard rails across the structure. It has been suggested that on concrete bridges and trestles additional safety against such accidents might be provided by carrying up a curb wall or parapet wall to an elevation above the rail level. It is considered, however, that this would interfere unduly with track work and tie renewals, as the ties have to be moved endways in removing and replacing them. In this case, also, stone ballast is used, which makes it desirable to disturb the track as little as possible in renewing ties.

The concrete trestles are built by company forces under the direction of the Bridge Department. For the construction of the first of these structures, falsework was used, wooden piles were driven at each side, in line with the old bents, and the 16-ft. stringers were swung round to form 16-ft. caps for a temporary floor or deck. This enabled the old structure to be removed entirely, and the concrete trestle built without interference with traffic. In later work, the floor of the timber trestle is partly dismantled, and the concrete piles are driven to form bents intermediate with the old timber bents. The forms for the caps are then erected, and the concrete caps are cast in place, without interfering with traffic. This concrete is allowed to set for about 30 days. A part of the timber structure is then torn out by a wrecking crane or derrick car, and the same machine sets the concrete girder slabs in place upon the concrete caps. The track ties are supported temporarily on 6-in. blocking on the floor, ready for ballasting.

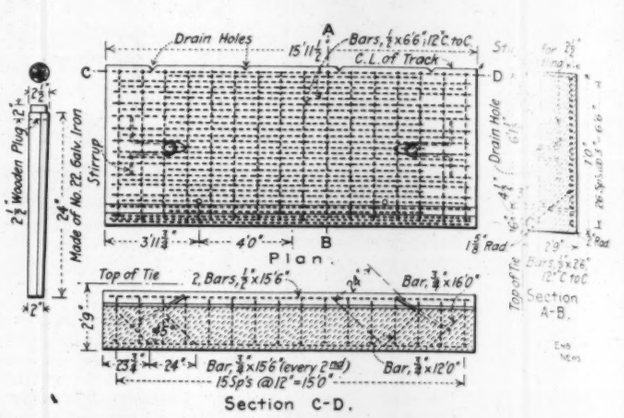


FIG. 8. FLOOR GIRDER OR SLAB FOR CONCRETE PILE TRESTLES.

(Two of these slabs, side by side, form the width of the floor.)

The concrete pile trestles now built or under construction by this railway number about 23; the longest structure is 435 ft. long, and the total length is about 2,700 ft. The maximum height is 18 ft. from the ground to rail level. The general design was prepared under the direction of Mr. C. H. Cartlidge, M. Am. Soc. C. E., Bridge Engineer of the Chicago, Burlington & Quincy Ry., and we are indebted to him for plans and other information.

Two designs for concrete trestles or viaducts of monolithic construction were illustrated in our issue of May 31, 1906. One of these, for the Cleveland, Cincinnati, Chicago & St. Louis Ry., had girder spans, while the other, for the Illinois Central Ry., had elliptical arches of 14-ft. span and 4-ft. rise. These structures were of moderate height, but a reinforced-concrete viaduct or trestle having a maximum height of 70 ft. was described in our issue of Dec. 12, 1907. This carries the Richmond & Chesapeake Electric Ry., and has spans of from 23½ ft. to 67½ ft. in length.

As of interest in this connection we give below an extract from the report of the Committee on Masonry, presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association:

Wooden trestles have been used quite extensively to carry track over small water courses. These trestles are usually constructed without abutments at the ends and in most cases (in order to allow for the slope of the embankment and for that of the depression crossed) the bridge is longer than the waterway requires. In many locations the features of short span and of adaptation to ground slope are especially advantageous, and the same arrangement may be desirable in planning structures of a more permanent character. One type of construction which is being used for low and medium heights of bridge in such locations with seemingly satisfactory results is the reinforced-concrete trestle. These structures usually have about the same length of span as the wooden trestle, are supported on reinforced concrete piles or thin piers, and have a solid floor, which itself may form the carrying beam from support to support. A number of railways have built structures of this type to replace wooden trestles.

Wabash Ry.—Mr. A. O. Cunningham, Chief Engineer, reports that this road has built nine of these structures, aggregating 640 lin. ft. These have [illegible] reinforced concrete decks (ballasted floor) and [illegible] relatively shallow foundations. The span[illegible] and the floor slab or deck 2 ft. 4 in[illegible] are 2 ft. thick at the top and hav[illegible] on each face. Vertical and horizont[illegible] pierced near the faces. The end suppo[illegible] of abutments. Some of these bridges[illegible] two years. No deterioration is ap[illegible]. Reinforced concrete trestles are used entirely by Wabash Ry. to replace wooden trestles where an opening larger than can be served by a 4-ft. pipe is required. Mr. Cunningham considers this style of structure more durable than any other.

Chicago, Burlington & Quincy Ry.—Mr. C. H. Cartlidge, Bridge Engineer, reports that the road has over 2,000 ft. of reinforced-concrete trestles in service. About 1,500 ft. are trestles built with reinforced-concrete piers and slabs (ballast floor) with spans from 14 ft. to 25 ft., and about 600 ft. are trestles resting on concrete piles with spans from 14 ft. to 16 ft. and with the same type of deck. The piers are from 18 to 30 ins. thick at the top and have the usual batter. In the pile trestles, a double row of piles with a cap of extra width (or a thin pier) is placed at the end of every fifth span.

The company is extending the use of both concrete pile trestles and pier trestles as rapidly as the wooden pile trestles on the main line require reconstruction. This type of construction is confined to places where the structures are free from excessive drift or ice. As a usual thing the pier trestle has its foundation upon soft wood piling, cut off at a point where the ground is always moist. The pile trestle has not been used in bridges having a height greater than 18 ft. In nearly all of these bridges the slabs forming the decks are cast in forms at some convenient place and later are transported to the bridge site and set in place on the piers or pile caps.

Cleveland, Cincinnati, Chicago & St. Louis Ry.—Mr. O. E. Selby, Engineer of Bridges, states that in 1906 the road built two reinforced-concrete structures near Lawrenceville, Ill., one 419 ft. in length and the other 189 ft.* The span is 20 ft. in the clear. The piers are 2 ft. 3 ins. thick at the top, with batter of 1:24, except that every fourth pier is 5 ft. thick at the top and the deck here has expansion joints. The sides of the deck form girders, designed as deep beams, the floor being reinforced transversely to carry the loads to these girders. The deck was built monolithically.

As to the cost of single-track structures: the Wabash Ry. states that in ordinary conditions the trestles referred to cost about $20 per lin. ft., plus $500 for the two abutments. If abutments are omitted and a free earth slope is allowed, two additional spans must be provided and the total cost will be increased. The Chicago, Burlington & Quincy Ry. estimates the cost of the reinforced-concrete pile trestles at from $30 to $35 per lin. ft. for ordinary heights. The cost of the structures resting on thin piers and pile foundations is given at $40 per lin. ft. and upward. The C., C., C. & St. L. Ry. gives the cost of its two structures as about $21 per lin. ft. Experience indicates that these structures will be a durable and satisfactory type for use in replacing wooden trestles of low and medium height under conditions which otherwise warrant the expenditure.†

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*Engineering News, May 31, 1906. This article described also a type of concrete viaduct used by the Illinois Central Ry. and having elliptical arches of 14 ft. span.

†The average cost of single-track timber trestles 20 ft. high is given as follows in Orrock's "Railway Structures and Estimates": Pile trestles, $13.91 and $12.25 per lin. ft., with bents spaced 12 ft. and 15 ft. apart c. to c. respectively; frame trestles with bents 15 ft. apart, $11.50 per lin. ft.—Ed.

Concrete Piles Used in the Steamship Terminals at Brunswick, Ga., and in the Navy Yard Pier at Charleston, S. C.*

By M. M. CANNON,† M. Am. Soc. C. E.

In January, 1906, the Fore River Shipbuilding Co. was commissioned by the Atlanta, Birmingham & Atlantic R. R. to design and construct a steamship terminal at the end of the railroad in Brunswick, Ga. Brunswick has an excellent harbor; but the waters there are so infested with the teredo that untreated pine piles are of no value after about two years' time. The first proposition that we encountered was to determine upon a type of construction that would be economical and permanent, and after much investigation it was decided to use reinforced-concrete piles.

TEST PILES.—I made two reinforced-concrete piles at the Fore River Shipbuilding Co.'s plant in Quincy and conducted a number of experiments with them. They were 14 ins. square, one about 45 ft. long and the other about 20 ft. The wooden form in which the piles were molded had two sides to it, the top being open. The proportion of cement, sand and stone in the concrete was 1:2:4. Four reinforcing bars of round, soft steel extended the full length of the pile, with hoop reinforcement of ¼-in. round steel clips placed 12 ins. apart on centers. The piles were 14 ins. square to within 10 ft. of the bottom, the last 10 ft. being drawn in until they were 8 ins. square at the bottom. They had a 1½-in. diameter water jet extending almost the entire length, or to within about 2 ft. of the top.

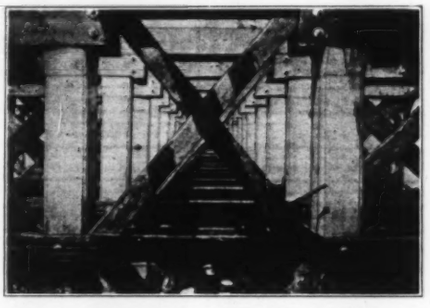
The concrete was poured into the forms and kept sprinkled for about seven days and not moved or disturbed for at least three weeks after the piles were cast. At the end of that time the piles were picked up by means of a locomotive crane and taken to the shore at Weymouth Fore River, the bottom there being sandy and having coarse gravel in it. The longer pile was driven between high and low water mark by means of the water jet and hammer until it had penetrated 18 ft. into the bottom and allowed to remain there until the tide went out. In the meantime we drove the small pile twice, one by means of the water jet and the second time without the water jet. The second time the head of the pile was pretty badly shattered by the hammer. We also drove an oak pile about 15 ins. in diameter at the top and about 10 or 11 ins. in diameter where it went into the ground. It was driven within 5 ft. of the concrete pile. After the tide went out an attempt was made to pull the concrete pile over or break it. A chain was fastened about 8 ft. above the ground and to that two double blocks and a 4-in. line were attached. One block was fastened to an adjacent pier and the free end of the tackle taken to the gypsy head of a pile driver engine, four turns being taken around the gypsy head, one man holding it and 80 lbs. of steam on the boiler. Ten or twelve attempts were made to pull the pile over but were not successful. Four more turns of the fall around the second gypsy head of the engine were necessary to break the pile on the fourth attempt. The oak pile was then broken on the first attempt under exactly the same conditions.

Afterward, in observing the reinforcement of the broken concrete pile, which consisted of four bars about 2 ins. from the outside surface of the pile, we found that in putting the tackle on the pile, instead of getting it at right angles to one face, we got it so that it pulled diagonally on the pile, and the rod that broke was the rod on the back corner. It broke right at the ground, the other rods bending over. Unfortunately, the rods were welded and the weld in the broken rod came right at the ground. Subsequent examination showed that not more than 50% of this weld had caught. If we had placed the tackle at right angles instead of diagonally I do not believe we should have broken it.

CONSTRUCTION.—With this information at hand we proceeded to design the terminals at Brunswick, starting construction July 5, 1906. The land on which they were located was a piece of marsh 200 acres in extent, filled in by means of hydraulic dredges. The terminals consisted of two piers, one 500 ft. long and 140 ft. wide, the other 900 ft. long and 140 ft. wide, with a coal trestle and a coal pier about 300 ft. in length and a basin 1,700 ft. long and 250 ft. wide. At the head of each pier were two warehouses 400 ft. in length and 80 ft. in width; there was also a power-house 125 × 40 ft. Underneath the piers the concrete piles were used for the bearing piles entirely. They were driven on 12-ft. centers both crosswise and lengthwise of piers. The piles used under the terminals ranged from 30 to 51 ft. in length and weighed from three to five tons each. The reinforcement was practically the same as that used in the test pile at Fore River, except that we used four 1¼-in. bars. At the head of the pile electric welded wire reinforcement come down about 4 ft. It was placed there to help stand the shock from hammering. The piles were 16 ins. square to within 10 ft. of the bottom and 8 ins. square at the bottom. They had a 4-in. shoulder 16 ins. from the head cast on two opposite sides that left a tenon at the head of the pile 8 by 16 ins.

The forms were made in one piece the entire length of the pile, the corners being beveled 1 in. The concrete was mixed in the proportions of one part cement, two parts sand and three parts broken stone and mixed very wet. In fact, the rule we observed for the amount of water in concrete was determined entirely by the distance the concrete was carried in wheelbarrows, the mortar being kept just moist enough so that the stone would not settle to the bottom of the wheelbarrow. At first stone from 1 in. down was used. The concrete was made in a mixer and wheeled in barrows to the forms. Great care was used in tamping, as many as seven men being used to each pile, and the casting of each pile was made one continuous operation. After the piles were made the forms were removed in twenty-four hours. The piles were then kept moist for seven days, at the end of which time they were picked up by means of a traveler and chain bridle and moved to the storage place, where they were kept for two weeks longer. At the end of that time they were taken to the floating pile drivers and driven.

When the first piles were driven we endeavored to pursue the same course as had been followed at Fore River in the experiments. A cast steel cap, sliding in the leads of the pile driver with a 4,500-lb. hammer was used in the driving of the piles. In the bottom of the cap was placed some rope and rubber and in the upper part a wooden block which the hammer struck. The cap was made to fit over the top of the tenon in the pile. It kept the pile from turning, so that in driving it could not get out of position, a very important thing, for it was necessary in this work to get the piles in exact position and keep them there. The first week we attempted to drive them by means of the water jet and



Pier at United States Navy Yard, Charlestown, S. C., Showing Method of Bracing Concrete Piles.

hammer, but succeeded in getting down only 4, 5 and 6 piles a day. The piles were 51 ft. long and fully 40 ft. of them were driven in the ground. The 1½-in. pipe of the water-jet was carried only one-third the length of the pile, coming out of the pile at the ground level in the shape of a reversed curve. We then used a separate piece of pipe on the pile driver long enough to extend down and to fit into the other pipe where it came out of the pile. That upper piece was taken out and used over again, the object being to save pipe, and we were able by this means to save from 25 to 30 ft. on each pile. We also found it feasible to use a jet the same size the entire length of the pile. Out of all the piles we drove there were not more than one or two instances where the pipe clogged from driving. The jet seemed to be successful in keeping it open.

We were rather discouraged that it took so long to drive the piles with the water jet and decided to try some other method, finally deciding on the scheme of raising and dropping them. A wire bridle was fastened around the top of the pile, by which to lift it, the hammer and cap being allowed to remain on the top of the pile as an additional weight. The piles were raised from 18 ins. to 2 ft. and dropped. By this method we increased the rate of driving until some days as many as 27 to 30 piles were driven in fourteen hours. The piles average from 30 to 51 ft. in length. On account of the water jet boring a hole ahead of the pile, it was found necessary in driving to shut off the jet and drive the last few inches by means of the hammer, the distance to be determined by experience according to the character of the bottom we were driving in. If we had good clear sand, we used to shut off the jet and drive the last 8 or 10 ins. with the hammer without any jet, the hammer dropping from 6 to 8 ft. The man running the level could determine very easily after he had become accustomed to it when to begin driving with the hammer.

The character of the bottom in the Brunswick work varied considerably. We had good clear sand, clay as hard as any around Boston and some the hardest I have ever seen. Also we had to drive through a stratum of soft rock composed of shell, sand and lime which was harder than any coral, and have driven many reinforced-concrete piles through 2 ft. of it. Afterward we pulled some piles up that had been driven through this material and found the edges of bottom of pile just slightly rounded off. About 50% of the piles driven were through the above material.

At the head of the piers we drove a bulkhead of 6 × 14 in. reinforced concrete sheet piling. The piles had four reinforcing bars and one side of the bottom was beveled off the same as with wooden sheet piling to keep them together. We used no water jet on the inside of these piles, but on the outside, and in that way saved considerable pipe. The sheet piling was of the same mixture of concrete as used in bearing piles, the proportions being 1:2:3, with stone of 1 in. in size. We filled in behind the bulkhead to a height of 12 ft.

Under the power-house we drove some concrete piles; in fact, the entire building is supported on them, 14 in. square and 25 ft. long, with the same reinforcement as we used for the piers. But this method was abandoned afterward on the other work, for the reason that it was found we could drive pine piles, cut them off at the water level and put concrete piles on top of them cheaper than we could drive concrete piles.

We had several severe tests of concrete piles on these piers. One of the steamers running on this line (they are boats of about 1,800 tons net and carry 3,000 tons of freight) came into the harbor on her maiden trip. It was the first steamer to arrive and came before the outer end of the first pier was finished. In order to bring this steamer to her birth a 9-in. hawser was fastened around the tenon of one unsupported concrete pile, about 32 ft. of which was above the ground level. The tide runs at this location exceedingly fast and the one pile successfully withstood the test of pulling this vessel against a rapid running tide to the pier. At another time one of the steamers ran into the pier owing to misunderstanding of signals in the engine room and broke a number of pine piles, but the concrete ones successfully withstood the shock. I have seen rails piled on deck of pier that brought a load of 60 tons on each of 6 piles with no settlement whatever; also lumber that caused a load of 40 tons per pile.

CONCRETE SHEET PILING FOR BASIN.—The basin previously mentioned is 1,700 ft. long by 250 ft. wide. The construction in that is perhaps unique and more interesting than the concrete bearing piles. The work was done by Mr. W. L. Miller, of Boston.

We built a bulkhead with concrete sheet piles, 18 ins. square and 45 ft. long and weighing 7 tons apiece. Pine piles were driven and a platform built on them on which the concrete piles were made. At the end the piles were beveled off to 12 × 18 ins. The reinforcement of these piles consisted of four ¾-in. corrugated bars running the entire length of the pile. For the lower two-thirds of the pile, that part from low-water mark down to the end, two 1¼-in. corrugated bars were put in to form a truss to take the strain where the maximum load came on the pile. We used a 2-in. water jet instead of a 1½-in. and found it much preferable. These piles had a tongue and groove on them. The proportions of concrete were 1:2:3, the same as in the other work.

The piles were made on the platform, 20 of them being cast in a day. They were allowed to set and kept moist seven days, at the end of which time they were picked up by means of a lighter, carried away to the storage pile and allowed to remain three weeks longer before being driven. The joints between the piles fitted very close, in fact much better than wooden sheeting. The bottom through which the piles were driven varied, I think, more than in the case of the other piles. Sometimes it was sand, then again very hard blue clay. In the case of these piles we drove them the entire way by churning, not using any hammer at all.

The anchorage consisted of two double rows of plain yellow pine piles from 35 to 40 ft. long, the first row 25 ft. from the bulkhead and the second row 15 ft. further back than that. Also in front of these piles dead men were placed and the front row was connected with the concrete sheet piling by 2½-in. rods in every other concrete pile. On the front of the sheet piling we constructed a concrete wale of 12 ins. wide and 16 ins. deep, in which heads of rods were imbedded. Two 1-in. corrugated bars were placed in it for reinforcement. After the rods had been placed and the concrete wale thoroughly set, the nuts on the anchor rods were set up as tight as possible and the filling deposited back of the bulkhead. After the filling had been completed (the bulkhead being 3,700 ft. long) we examined the concrete wale; in fact, it was examined more or less often for fully three months afterward, and we never found a crack in it, which seems to show positively that the bulkhead has never moved. I believe if it had moved it would have shown in the cracking of the wale before any other place. The filling in behind the bulkhead, of course, gives an admirable foundation for the erection of warehouses, and reduces maintenance to a minimum.

The number of piles driven on the Brunswick work was 5,426. The approximate cost of the terminals was

*Paper presented to the Boston Society of Civil Engineers, Sept. 16, 1908. Reprinted from the Journal of the Association of Engineering Societies, January, 1909.

†Care of W. L. Miller, 19 Milk St., Boston, Mass.

$1,500,000. The two piers built cost about $1.40 per sq. ft.; that is, figured on the surface of the dock. The cost of the 18-in. bulkhead was $75 per running foot complete, exclusive of the dredging. The work started July 5, 1906, and was completed May 1, 1907, or in eleven months. Mr. Miller built the basin, starting the first of May and completing it the first of November, six months.

PIER AT CHARLESTON, S. C., NAVY YARD.—This pier, 60 ft. wide and 520 ft. long, is built upon cast reinforced-concrete piles of the same general design as those used in the Brunswick work. They are 55 ft. long and 18 ins. square to within 8 ft. of the bottom and then taper off to 12 ins. square. The reinforcement of these piles consists of four 1¼-in. twisted bars and two ⅞-in. bars. The government asked the contractors to submit their own design for concrete piling, the cross-sections of which should be equal to 18 ins. square and 7 sq. ins. of reinforcement, and we would get the best arrangement of the reinforcement by the use of the rods mentioned. The 1¼-in. bars are placed in the corners of the pile, 2½ ins. in from the outside. The two ⅞-in. bars were put in the pile 2½ ins. in from the surface on opposite sides and on a line across the pier.

These piles were made of the same general scheme as the sheet piling at Brunswick. They were built on a platform, wooden forms were used, a 2-in. water jet 22 ft. long was put into the pile and for the rest of the distance was outside. The piles were kept moist seven days and then picked up by means of a lighter and carried away to the storage pile. The scheme used for lifting these piles, which weighed 10 tons each, was to use a bridle, consisting of two chains kept apart by a piece of yellow pine 18 ft. long. Hanging down from each end of this piece of timber were two big timber hooks. These were used to lift the concrete piles. We had no trouble in lifting them. In fact, of all the piles driven at Brunswick or at Charleston, I never saw one broken from lifting it. We carried them from the storage pile to the site where the work was being done on lighters.

The scheme of superstructure of this pier was practically the same as in the Brunswick work, except that it was heavier. The shoulders on each side of tenon for supporting the girder caps were 8 ins. in place of 4 ins. as at Brunswick, and the tenon 10 to 18 ins. These girder caps were fastened to the tenon by four 1-in. bolts. We did not fasten the bolts through the pile at all, but clamped them to the tenon. (See figure.)

The bottom through which we drove the piles at Charleston consisted of marl, which is a yellow clay that is extremely hard and has about 15% of sand and is very sticky. When it comes out in the open air inside of a few hours it is so hard that you have to use a hammer to break it. It is almost stone. For the first 50 ft. of the pier the piles were driven through 38 ft. of this marl, no sand whatever, but the very hardest kind of marl. The driving was done entirely by the churning process until we got within two or three inches of the bottom, when they were driven to grade with a 4,500-lb. hammer.

The work was started May 18 and was completed in three and a half months. The cost was $2.60 per sq. ft., almost double the cost of the Brunswick work, due principally to the fact that the piles were 10 ft. on centers where we had 12 ft. on centers at Brunswick, and to the heavier construction. For bracing the piers at low-water mark we put a pipe through the pile when casting it, which gave a hole 6 ins. above low water through which a 1-in. bolt fastening two 6 × 12-in. low-water girders was placed. Also cross bracing was fastened to the superstructure and to these low-water girders.

The test-load required in the case of the Charleston pier was 400 lbs. to the sq. ft. or 20 tons to the pile and the government had the privilege, of course, of choosing any piles they wished us to test; instead of testing the piles at 20 tons to the pile, we loaded them to 30 and kept the load on for 48 hours. The piles stood up so well to this test that the government engineers were able to find no settlement whatever.

DISCUSSION.—In the discussion which followed the paper some additional facts regarding this large pile-driving contract were brought out. This additional information included the fact that 100 lbs. pressure had been used in the water jet, this proving equally as effective as the more generally used 150 lbs. and not causing so great a wear on the pipes as the latter. For all of this sea-water work a cement having not over 8% of alumina was prescribed, and although at first this specification was hard to follow, a cement was soon found in which only two barrels, out of the amount used on the whole work, were disqualified on account of an excess of alumina. Care was taken that nothing but fresh water materials entered into the mixture.

Some of the piles in this vicinity have been in place in the ocean for nearly three years, but there is not the slightest signs of deterioration such as is often observed in concrete marine structures farther north. It is the opinion of the engineer that this is due to the absence of ice or frost which, at least, starts disintegration in the northern climates, and which no doubt accelerates the destruction when once started.

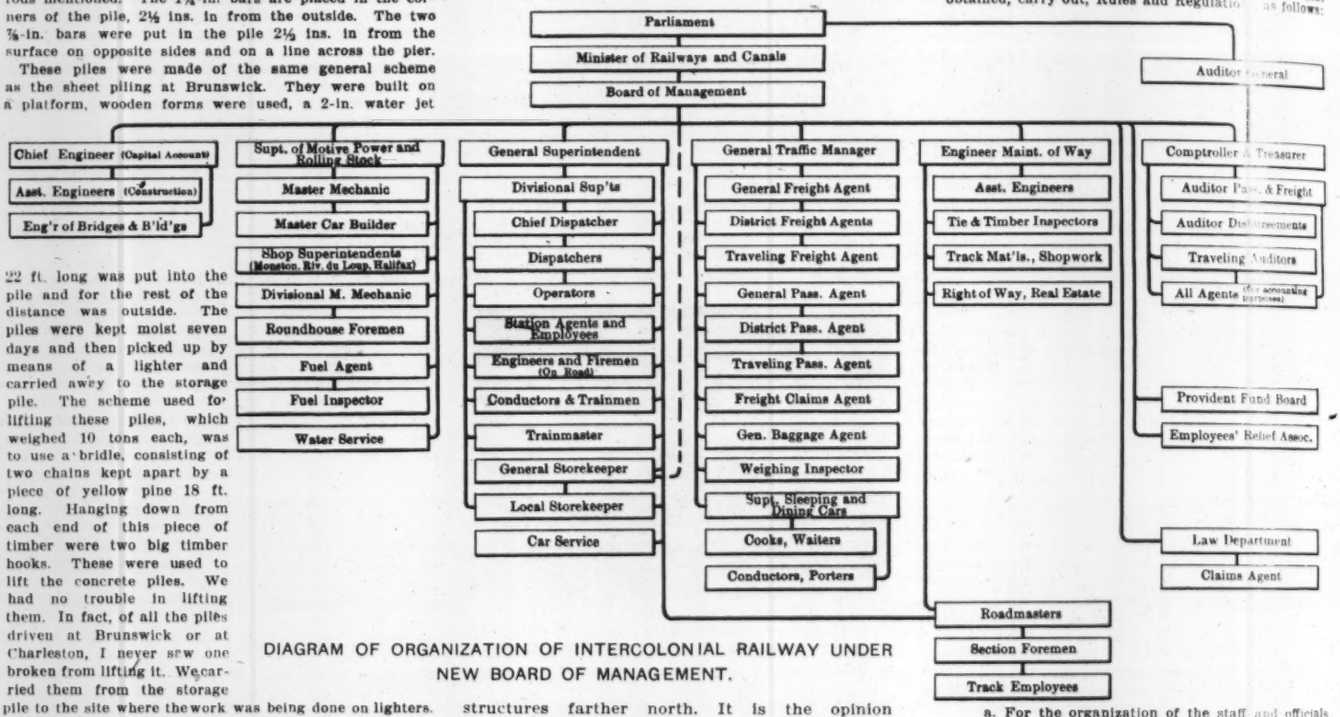


DIAGRAM OF ORGANIZATION OF INTERCOLONIAL RAILWAY UNDER NEW BOARD OF MANAGEMENT.

Reorganization of the Intercolonial Ry.

The Intercolonial Railway, owned and operated by the government of the Dominion of Canada, has long been a vexatious problem of management to the Dominion authorities. It has been the plaything of all the storms of politics and the preferred object of the Opposition's attacks. Incidentally, gross inefficiency has often been charged against its management. An attempt has now been made to rescue the railway from these depressing conditions by establishing a new form of management. A central Board of Management, under the direct supervision of the Minister of Railways and Canals, has been substituted for the single general manager.

The Intercolonial extends from Halifax and St. John westward to Montreal, and is connected with Sydney, Cape Breton Island, and with the Prince Edward Island Ry. Its total length, including the latter line (bought in 1873), is 1,449 miles. Ever since its opening (1876) it has had a single-headed organization, the official in charge being called "General Manager, Government Railways."

On the recommendation of the Minister of Railways and Canals, the Governor-in-Council has now abolished the position of General Manager, and has fixed a new managing authority, to be named "The Government Railways Managing Board," which is to consist of the following four persons:

M. J. Butler, Deputy Minister and Chief Engineer to the Department of Railways and Canals; to be chairman of the board.

David Pottinger, former General Manager of the Intercolonial Ry.

E. Tiffin, hitherto Traffic Manager of the Intercolonial Ry.

F. P. Brady, formerly General Superintendent of the Lake Superior Division, Canadian Pacific Ry.

What this board is to do is defined as follows in the order:

The said Board to supervise and direct the departments of the railways owned or operated by the Government of Canada.

The duties and powers of the said Board shall be as hereunder defined, namely:

They shall have the powers usually vested in the executives of railway corporations.

They shall prepare, subject to the Government Railways Act, and the Provident Fund Act, and, with the approval thereto of the Governor-in-Council first obtained, carry out, Rules and Regulations as follows:

a. For the organization of the staff and officials of the railways.

b. For the conditions of employment in the railway service.

c. For the purchasing of supplies and the sale of materials.

d. For the ascertaining and collection of the railway tolls, dues and revenues.

e. Those to be observed by the conductors, engine-drivers and other officers and servants, and by all companies and persons using such railways.

f. Those relating to the rolling stock to be used in the trains in such railways.

They shall meet for the transaction of business at least once a month, and shall keep regular minutes of each meeting.

They shall report to the honorable the Minister of Railways and Canals, monthly, and shall also make a special and comprehensive report at the end of each fiscal year, on expenditures and receipts of the Government roads, and on all occurrences and transactions of importance, and shall, further, furnish such reports as may be, from time to time, required of them by the Department of Railways and Canals.

The members of the board, except Mr. Butler, the Deputy Minister, receive a salary of $6,000 per year, and are required to devote the whole of their time to the work.

The organization of the Intercolonial Ry., under this board, is summarized by the diagram given above.

This order was approved April 20, 1909, and is now in effect. The detail work of management has been divided thus:

The chairman will be charged with all matters of construction, all questions of general policy, conferring with the Minister when necessary. Mr. Tiffin will act as General Traffic Manager. Mr. Brady will be General Superintendent in charge of transportation. Mr. Pottinger will have general supervision over the Accounting Department, and will act as chairman of the Provident Fund Board and the Insurance Association. These specific duties are in addition to the duties of the members on the board.

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Entered at the New York Post-Office as Second-Class Matter

Considerable space was given in our issue of March 25, 1909, to the new city charter framed by the Charter Commission and adopted by the people of Berkeley. One of the unique features of the charter was the provision for nomination of the few elective officers by petition, without any of the usual party machinery of primaries or conventions. Any 25 voters who can agree on a candidate and get the man so agreed upon to accept the candidacy, can, under the new Berkeley charter, nominate a mayor, an auditor, or one or more men for the four memberships in the city council or in the school directors (the Mayor constitutes the fifth member of the council, and the councillor who is appointed at the head of the city department of finance and revenue becomes the fifth member of the school directors).

Through the courtesy of Mr. Wells Drury, Secretary of the Berkeley Chamber of Commerce, we are enabled to give the general results of the election. Of the four candidates for Mayor, Mr. B. L. Hodghead received 2,521 votes, which gave him a majority of 24 over the three other candidates. There seems to have been more unanimity as to the leading candidate for auditor, who received 2,945 votes and a majority of 557 over the other three candidates. Although the clear majority secured by the mayor-elect was only 24, he was nevertheless the unmistakable choice of the people, both because he did have a majority over the other three, and because the candidate who came nearest to him as a vote-winner received only 1,404 votes.

Under the Berkeley election plan, provision was really made for two election days, the second to take place only in case of non-election to one or more of the offices through the fact that no candidate receives a majority vote. In such an event, the first election becomes virtually a primary, and a second election must be held three weeks later. At this election, only the two highest of the rival candidates for any office are voted for. The second election will be required in Berkeley, to select both the four councillors and the four school directors. For council members the votes of the highest four ranged from 2,138 to 1,380, and of the second four from 1,235 to 870. The votes were not far different for school directors. The list of the latter is headed by a woman (the only woman candidate at the election) who had 1,964 votes against the 1,930 of her closest rival.

We note this election in some detail, inasmuch as the general plan outlined above, as provided in the Berkeley charter, seems likely to be proposed for adoption in many other places in the United States during the next few years. There is really little that is new in the plan, if one looks further than our own country. Nomination of municipal officers by petition has been common in England for scores of years. Where only one candidate is put forward, as frequently happens, no election for that office is held. To those whose only or chief interest in a municipal election is to see the best man and the best municipal policy carry the day, the nomination-by-petition plan seems infinitely superior to the present convention or primary methods of nomination, even where the direct primary prevails. Berkeley deserves credit for having had the courage to adopt what for American cities is so much of an innovation, but what has worked so well abroad for many years past.

The wooden trestle has always been a typical feature of American railway practice. It has been severely criticised by foreign engineers, but it has undoubtedly served a most useful purpose. This was particularly the case in the pioneer days of railway construction, when in most parts of the country timber was exceedingly cheap and earthwork, by reason of high priced labor, always expensive. There are undoubtedly many places still where the wooden trestle is a useful and proper adjunct to railway construction. A notable instance is the new line of the Chicago, Milwaukee & St. Paul through the densely wooded regions bordering the Pacific Coast. Taking the country as a whole, however, the rapid and permanent increase in the cost of timber, combined with the great reduction in cost of earthwork, have made the wooden trestle no longer economical.

It has for some time been the expectation of those familiar with good practice on foreign railways that the time would come when the wooden trestle would disappear from American railway lines. This has, in fact, happened already to quite an extent. An enormous mileage on wooden trestles has been eliminated from main line roads during the past 15 to 20 years; and much more such elimination is bound to take place as old structures reach their limit of life and the cost of replacing them increases.

In the present issue, however, we describe and illustrate a plan for perpetuating the wooden trestle in concrete, which has been adopted to a considerable extent on one of the principal Western railway lines. Admittedly, the concrete trestle eliminates many disadvantages of the short-lived wooden structure. If properly made, it should be permanent. It is free, of course, from the danger of fire, which is one of the chief objections to the wooden trestle; it provides a solid ballast floor, and the cost of maintenance should apparently be very small. On the other hand, it is a little difficult to see the object for building the structure. Wooden trestles have been built because they were cheap, but the concrete trestle is not cheap. The figures given for cost per lineal foot, for structures with a maximum height of only 18 ft. are $20 to $40.

Computation shows embankments to be very much cheaper than this. They are cheaper even when the structure is of much greater height, or even when the ground on which the fill is made is very soft, so that the embankment has to be given a very broad base. The only places where it can be claimed that the trestle is superior to the embankment, therefore, are the locations where a large waterway is essential.

It is one of the disadvantages of the pile trestle, however, that it offers too much obstruction, where a waterway is required. It is also liable to be clogged by floating drift, and many trestle failures and bad accidents have resulted from this cause. It would seem to us, therefore, that under present day conditions, if a structure is required to pass a large volume of water, something better than the pile trestle should be chosen, even though the trestle be made of indestructible material. It will be evident that the larger waterway, which piers and longer spans will afford, will allow the embankments to be extended further, thereby reducing the total cost of the structure.

Anyone familiar with European railway practice in the protection of trains on viaducts can understand how reckless much of our American practice must seem to foreign engineers. If viaducts must be built, is it not better to adopt substantial piers, with girders or arches between them, and make a structure which can carry a parapet sufficiently massive to guard a derailed train from going over the edge?

Until quite recently it has been next to impossible to secure comparable sewerage statistics from half a dozen cities of the United States. Thanks to the Committee on Uniform Sewerage Statistics of the Sanitary Section of the Boston Society of Civil Engineers, this condition is changing. A few years ago, the committee named put much hard work on a schedule for the uniform reporting of sewerage statistics, and now for the second time it has been able to tabulate statistics relating to the sewerage systems of a considerable number of cities. The latest tabulation, covering the year 1907, has appeared in the March number of the Journal Association of Engineering Societies. A total of 48 cities are now represented. About half of these are located in Massachusetts, and the others are widely distributed—one or more being in Canada. The statistics are quite comprehensive, and include information on sewage disposal by purification and otherwise, and also on cost of maintenance. We call attention to the statistics, not to summarize or criticize them, but merely to give well-deserved commendation to the committee which has been named and to the cities which have made the present tabulation possible. In addition, we express the hope that this tabulation will stimulate a large number of other cities to so keep their records that extracts from them may be included in future tabulations. It appears that only a paltry half-dozen cities have as yet made use of the schedule in connection with the annual reports of their sewerage departments. It is to be hoped that the number so doing will be rapidly increased.

The Question of Improved Rail Fastenings.

The necessity of an improvement in the fastenings of rails to ties in American railway track has been apparent for several years, more especially on the main lines carrying fast and heavy traffic and subjected to the enormous wheel loads of modern locomotives and cars. Very little has been done, however, towards the design or trial of such improvements, and both the practical and the economic sides of the question have been overlooked to a very large extent. The economic side has been brought to the front recently in its relation to the economics of the use of treated ties, although the relation to untreated ties is equally important. The question is one of efficiency and safety as well as of economy.

In a report presented at the recent annual meeting of the American Railway Engineering and Maintenance of Way Association, the committee on wood preservation stated that there is urgent necessity for work upon an improved rail fastening in connection with the use of treated ties, and further remarked that:

> It is evident from present results that economic life of treated ties cannot be obtained without an improved rail fastening.

In its conclusions, also, the committee pointed out that preserved or treated wood may be destroyed by mechanical action long before it is decayed. Another report presented at the same meeting, by the committee on ties, recommended the use of chemically treated ties and the protection of such ties against mechanical wear by

means of tie-plates, screw-spikes, etc. In the discussion of the former report, the matter of rail fastenings was not touched upon. In the discussion of the latter report, however, an important change was made in recommending that "all ties" should be protected against failure from mechanical wear. An objection made to this change was that it would weaken the force of the argument as to the economic necessity of protecting ties which have been subjected to preservative treatment. It should be noted, however, that very often the annual cost (and sometimes the actual first cost) is higher for untreated than for treated ties, so that the economic importance of getting the full life of the tie may be as great for the former as it is for the latter.

The specific recommendations (noted above) for the use of screw-spikes and tie plates as means of protection to the ties was eliminated, however, during the discussion. This was somewhat unfortunate, in that it brought the recommendation down to a mere general statement. It was due in part, no doubt, to a misapprehension as to the value of the screw-spike. The old objection was brought up that the screw-spike holds the tie firmly to the rail, so that where there is any motion due to insufficient ballast support the tie will work up and down with the rail, and thus disturb the ballast. The ordinary spike under such conditions (and in fact under any condition) is pulled out of the tie sufficiently to allow the rail to move independently of the tie.

This independence between tie and rail may be permissible on second-class track, although it must be understood that where tie-plates are not used it necessarily results in mechanical wear of the tie by the rail. Furthermore, under such conditions the tie does not remain unmoved (as appears to be assumed); on the contrary, there is movement of both rail and tie independently of each other, with a consequent effect upon the ballast bed. Even if we grant (for the sake of argument) that a somewhat loose attachment of the rail is desirable on second-class or inferior track, it does not follow that we must adhere to the common spike. A screw-spike screwed home and then slackened would be a more permanent and effective fastening, as there would be little liability of its working loose or losing its grip in the tie. With a loose drive-spike, however, there is a continual and increasing loosening, with a consequent reduction of the frictional hold. In fact the alternate pulling of the common spike by the rail and its redriving by the trackman's hammer have a large influence in reducing the life of the tie and the efficiency of the fastening.

The idea that the movement of the rail independently of the tie is advantageous or even necessary, has been promulgated by manufacturers of ordinary spikes as a stock argument against the screw-spike. That this is not an argument against the latter we have shown above, since the screw-spike may form a practically permanent fastening even while allowing play of the rail. It would seem, however, that manufacturers would have served their own interests better by giving more attention to the perfection of an improved fastening which could be introduced at a price that would command the attention of the railways. The inefficiency of the common spike, and its weakness as a feature in track construction, are pretty generally recognized and are being proved beyond dispute. The introduction of an improved fastening, therefore, may be regarded as inevitable. The objection to the screw-spike by reason of its holding the rail to the tie was dealt with by us some five years ago, and we quote the following from an editorial note in our issue of Aug. 11, 1904:

> The inventor of an improved drive spike claims that a screw spike has such a hold in the tie that in case of unevenly tamped ties it will not pull out a short distance as a spike does, but will raise a low tie from its bed and cause pumping of the ballast from under it. Let us consider this objection. Suppose a spike is driven home in a low tie, and then pulled partly out again. Is such a rail fastening a safe one to hold a rail over which modern fast trains are run? It would seem to us that if a tie is so poorly tamped that the ballast is pumped from under it, it is out of place in a track carrying modern heavy wheel loads and fast trains. On railways of light traffic, using ballast of such a sort that ties heave badly in winter and require shimming to keep the track in surface, there may be good ground for this objection. But it does not seem to us to apply to railways of heavy traffic where the demand is for a more secure form of rail fastening.

It should be understood as a fundamental principle of railway track construction, that for first-class track carrying fast and heavy trains (at least) the rails and their supporting ties, together with their fastenings, should not form a heterogeneous combination of independent units. They should form a rigid and homogeneous structure, as much so as the cover plate and flange angles of a bridge chord or stringer. This side of the matter was noted in a paper on track construction read before the Western Society of Engineers by the late J. W. Schaub (Engineering News, June 13, 1907). In order to relieve the rails of the severe stresses due to lack of uniform tie support in the ballast, he proposed to support the ties on two lines of longitudinal I-beams, thus reproducing the conditions existing in bridge floors.

Thus far we have considered only the general relation of the rail fastening to the track structure. We may turn now to the design of the fastening itself. The defects of the common and (in this country) practically universal drive-spike have been set forth so often that we need not do more than simply refer to their damaging effect upon the ties (both by direct crushing and by causing conditions favorable to decay), and their inefficiency in holding the rail to the tie. Improvements have been made in the design of the spike, more especially as to sharpening the point and obtaining a well-shaped body. The flat head is susceptible of further improvement, as the fracture of the head in driving (especially when it comes down upon the rail) is a frequent trouble. In this respect something may be learned from European practice. But no matter how far the drive-spike may be improved it remains an inefficient fastening for rails carrying fast and heavy service; this is owing to its inherent defect in that its hold depends entirely upon the friction between the wood and the spike, and this is an uncertain and indeterminate quantity.

It is true that drive-spikes (or "hook spikes") are still used in some parts of Europe with satisfactory results. They are used as a rule, however, upon lines of lighter traffic, and in many cases also form a more secure fastening than the common spike of this country. In some cases the size increases (by a slight taper) from the neck to the beginning of a long wedge-like point. In other cases, the spike is octagonal and is driven in a bored hole, to the benefit of the life of the tie and the efficiency of the fastening. The head, also, is usually heavier than in this country. But while all this is true, the fact remains that the drive-spike as a fastening for main line track construction has been superseded by the screw-spike in some countries, and is being superseded in others.

Three other types of fastenings have been used: (1) screw-spikes; (2) bolts; (3) wedges or keys. Bolts are now practically unknown for this purpose, except that they are used in Europe to a limited extent, mainly for attaching the chairs of double-head rails to the ties. In general, however, round spikes or wooden tree-nails are used for these chairs. The rails in this case are not self-supporting, but require to be carried in the chairs; these are castings which give a large area of support upon the tie. The casting extends up on either side of the rail, and one side of the rail web bears directly against the upper part of the casting. On the other side, a tapered wooden block or "key" is driven between the rail web and the chair. In rare cases, a coiled flat steel bar is used, forming a hollow key of the same general shape as the wooden key. This chair and key support has been tried to a limited extent with tee rails in Europe.

Brief reference may be made to a type of wedge or key fastening which holds the rail by the edge of the base. This has been used extensively abroad with the Rendel pressed steel tie (as noted later), and to a small extent with wooden ties on a plan devised by [illegible] C. P. Sandberg. In this case the steel tie, [illegible] a tie-plate for the wooden ties, has lugs to [illegible] age the rail base. Between the lug and the rail [illegible] se is driven a tapering steel key, having its [illegible] face shaped to bear upon both the top and [illegible] of the rail base. Neither bolt nor key faste[illegible] have any practical application at the press[illegible] me.

We come then to a considerati[illegible] the screw-spike as an improved fastening [illegible] American railway track. It has the endors[illegible] of long and extensive use in Europe, wi[illegible] its value has been proved beyond questio[illegible] As shown elsewhere in this issue, it has [illegible] used in France for some 30 years, to the [illegible] tical exclusion of the drive-spike, and it[illegible] n general use as a standard track fastening [illegible] many other countries. Various modifications i[illegible] detail have been devised for holding the rail [illegible] allowing of its adjustment) and for increas[illegible] the hold of the spike in the tie, but the plain screw-spike remains as a standard device, wh[illegible] has long passed beyond the experimental st[illegible]

In this country, the screw-spike has been used only to a limited extent, and mainly in an experimental manner, with the natural result of giving varying results. In some cases where unfavorable results have been reported, investigation has shown that these results were due to improper use or placing of the spikes. Mr. W. C. Cushing, M. Am. Soc. C. E., Chief Engineer of Maintenance-of-Way of the Pennsylvania Lines (Southwest System), has prepared a paper on the use of screw-spikes as rail fastenings (of which an abstract is given elsewhere in this issue), and he implies that this fastening is not so generally used or so successful abroad as is generally understood. He refers to foreign improvements in screw-spike fastenings as proof that the screw-spike "is not a thoroughly efficient rail fastening." The fact is, however, that foreign railways have used the screw-spike so long and so extensively that they are seeking to improve upon it. In this country we have barely commenced its use. We have practically nothing but the common drive-spike, and it seems poor policy to delay the adoption of a fastening of proved superiority merely because this latter may be capable of still further improvement.

The greater holding power of the screw-spike has been shown by numerous tests and by long experience in service. This feature is admitted even by its opponents. Let us look at the improvements which Mr. Cushing mentions, and which he considers as forming an argument against the introduction of the screw-spike. The holding power of the screw is due to its projecting thread cutting into the solid wood and thus getting a positive hold instead of being held merely by friction against the sides. A certain amount of slackening and tightening may be required at intervals, in connection with maintenance work, but this will be less frequent and of less amount than where common spikes are used. The movement will eventually, however, produce some wear of the wood (especially in soft ties) and so reduce the grip of the spike. This trouble is reduced to some extent by inserting plugs or threaded dowels of hard wood in the tie, into which the spikes are screwed. This system is used by a number of roads, but cannot be considered as standard practice in any case. It is stated by Mr. Siegler, Chief Engineer of Track of the Eastern Railway of France, that there is track 20 years old carrying 80 trains per day, in which the screw-spikes (in oak and beech ties) hold as well now as when the track was built. The wear of the tie by the screw-spike, therefore, is evidently a matter of only secondary importance.

An improvement which has been used to a considerable extent, consists in cutting a recessed thread in the hole bored for the spike, and inserting in this a steel spiral which is compressed longitudinally and thus reinforces the wood lying between the coils of the thread on the spike. This is used both for new ties and for repairing worn holes in old ties. It has been tried in this country (Engineering News, June 21, 1906). While apparently satisfactory,

its use is not essential, as is shown by experience abroad. Nor is its use by any means general. The only other improvement mentioned is a device consisting of a split sleeve which is threaded on the outside and in the bottom of which is fitted a conical nut to receive the end of the screw spike. This nut has wings to spread the sleeve. The hole bored in the tie is enlarged for part of its depth to receive the device. As the spike is screwed down the conical nut is pulled up and (by the projecting wings on its surface) spreads the split sleeve and causes the exterior thread of the latter to bite into the wood. Both of these systems require special methods of application, and they are used only to a very limited extent as compared with the great mileage of track having the ordinary screw-spike fastening. While the above developments may be desirable or necessary in certain cases, they hardly need to be considered in discussing the comparative merits of the drive-spike and the screw-spike for American railway track.

An improvement which may be of greater importance, and which has been developed in Germany, is the use of a spring washer under the spike head. This takes up much of the jar and vibration, and tends to keep the spike tight and reduce wear of the spike hole. Its use, of course, is on the same principle as the use of spring washers and track bolts.

The screw-spike may hold the rail in either of two ways: (1) by the direct bearing of its head upon the rail base; (2) by means of a clip or washer interposed between the spike head and the rail. The former method is the more generally employed, and the latter is used mainly in connection with tie-plates of special form. Where the clip is used, it should give a good bearing on the tie as well as on the rail, and it is good practice to make it of such shape that its outer side will engage with a hole in the tie-plate, so as to distribute the lateral pressure.

The screw-spike has the advantage of maintaining the gage more uniformly as well as holding the rail more securely than the drive-spike. With the latter, the outward thrust of the rail tends to force the spike back and also slightly raise it. With the screw-spike, however, the positive hold of the thread prevents the raising of the spike, and it can give only by bending at the neck. This bending may be resisted by using a rail clip which gives a good bearing on the tie or on a tie-plate which has a shoulder so shaped that the spike head will bear uniformly on the rail at the inner side and on the tie-plate at the outer side. The desirability of reinforcing the common spike against the lateral thrust has been recognized in this country and various methods of support have been devised, none of which have been used extensively. Double spiking, or the use of two spikes instead of one, is common practice on curves, and a device has been tried which resembles a short spike driven at the back of the main spike. Some tie-plates are made also with ribs or lugs at the spike holes so as to support the back of the spike.

The rail fastening cannot well be considered without taking into account the use of metal tie-plates. These are designed to relieve the tie from the mechanical wear and disintegration due to the movement of the rail, and they become less necessary when the fastenings hold the rails and ties rigidly together. They have another advantage, also, in binding the spikes together, so that the inner spikes also resist some of the outward thrust of the rail. In the use of these tie-plates there is a great difference between American and foreign practice. In this country, the plate has been usually thin and with ribs or claws which get a hold in the tie and so form a self-attaching plate. In Europe, the plates are usually larger and heavier, and are without this self-attaching feature. They rely, therefore, upon the rail fastenings (or special fastenings independent of these) to secure them to the tie. There is thus greater difficulty in avoiding shifting and rattling of the plates. Some roads in this country are using flat-bottom plates, which are held only by the rail spikes.

The comparative merits of plates flat on top and those having a shoulder or rib to receive the outer edge of the rail base, have been widely discussed, but the present tendency is undoubtedly towards the use of the shoulder plate in order to relieve the spikes. Some interesting experiments with large and heavy tie-plates or chairs for tee rails on German railways are noted elsewhere. The general introduction of such chairs in this country is quite improbable, but for high-speed lines their use on curves may be found advisable, especially if they are so formed as to give a bearing against the web of the rail, as in the chairs for double-head rails, already noted.

Perhaps some reference should be made to fastenings for steel and concrete ties. For the latter, various arrangements of through bolts, hook bolts and screw-spikes have been devised; the spikes engage with wooden blocks or plugs, or with threaded sockets, embedded in the concrete. The use of concrete ties under high-speed traffic has not as yet been found very satisfactory, and their use is very limited. With steel ties, however, the case is different; their use is extending, and they are being laid on important main lines. As a rule, a bolted clip fastening is used, but this is capable of considerable improvement, especially in the way of affording greater lateral resistance to the outward pressure on curves. When the pressure is transmitted directly to the neck of the bolt and through it to the tie, the resistance is likely to be insufficient owing to the loose fit and the small area of bearing at the back of the bolt. In Europe, it is common practice to use a large hole in the tie and a rail clip or washer which fits into this hole, and thus supports the bolt. A very successful fastening employed extensively in India consists of a steel wedge or key driven horizontally between the rail base and a lug on the tie or a tie-plate. The face of the key is shaped to bear against the top and side of the rail base.

To return to the main point in closing, however, we may present two conclusions: First, the common drive-spike (with all its development of form) is an inefficient fastening for rails in track carrying fast and heavy traffic; second, in the screw-spike we have available a rail fastening which is known to be vastly superior to the drive-spike, and whose superiority is sufficient to warrant its adoption on its own merits, without waiting for the development of possible future improvements in its efficiency.

LETTERS TO THE EDITOR.

Protection Against Scour in River Bridge Piers in Reference to the Peoria Bridge Failure.

Sir: In reference to the accident to the Peoria Bridge described in your issue of May 13, 1909, p. 529, I would like to record my experience in placing foundations for railroad and highway bridges in the Ohio, Monongahela and Allegheny rivers, within a radius of 50 miles of Pittsburg, Pa. The general character of the bed of our rivers within the above prescribed district is alternate hard and soft gravel. A rock foundation cannot be obtained within the 50-mile radius, especially the Allegheny and Monongahela rivers, without going very deep.

Until about 1895 all foundations for bridge piers in our navigable rivers were what is known as timber grillage, placed on a gravel foundation prepared by dredging out the gravel in the bed of the river from 4 to 10 ft. The first pile foundation in this vicinity was adopted in the construction of the suspension bridge connecting the boroughs of Rochester and Monaca, Pa., about 25 miles down the Ohio River from Pittsburg, since when all important structures have been placed on wooden pile foundations; and until recently timber grillage with open caisson was the general method of construction.

Within the last few years, foundations have been dredged out as formerly, piles driven and cut off, and around them steel sheeting has been driven, and the space thereby enclosed filled with concrete to a depth of from 2 to 4 ft. above the top of the piles. After sufficient time for the concrete to harden the water has been pumped out and masonry built on top of these combined wooden pile and concrete foundations. The substitution of concrete for timber grillage has largely been brought about by the great scarcity of timber and the keen desire on the part of the engineers to save in this way millions of feet of timber.

There are nine bridges on the Monongahela River and ten on the Allegheny River, within a radius of 50 miles, with foundations on timber grillages, resting on gravel. The constant encroachment on the river banks by manufacturers on both the Allegheny and Monongahela Rivers, has so narrowed up the navigable channels that in five of these bridges, to my personal knowledge, the bottom of the grillage is above the bed of the river, and if it were not for the extensive riprap that is placed around each and every one of the above-mentioned 19 bridges, and especially the five, they would probably not survive the floods of a single year.

The Ohio River bridge, mentioned above, was thrown open to traffic in the Winter of 1896-7. The piles under the two channel piers (both in the river, supporting a channel span of 800 ft.) were driven throughout their length in gravel, and average about 12 ft. below the cut-off. In the early spring of 1907, after one of our largest floods in the Ohio River, I was called on to inspect one of the piers, which the company feared had scoured during the recent flood. To my great surprise, I discovered that the river had scoured under the upper half of the pier on the right bank 9 ft. below the cut-off, and had deposited the scour around the sides and lower part of the lower half from 4 to 6 ft. above the bed of the river. Several barges of gravel were hurriedly dumped around the upper sides and nose of the badly undermined pier and upon this heavy riprap placed around the pier, extending out on the two sides and in front a distance of from 15 to 20 ft. No settlement in the superstructure or cracks in the masonry were discovered at the time, or have appeared since, and it is my impression that there was no settlement.

Notwithstanding the fact that large quantities of lime and sulphur coming from our mines form deposits on the bed of the river, and a hard crust that often extends to a depth of three feet, in places as hard as concrete itself, my universal experience has been that it makes no difference whether a pier has for its foundation a grillage resting on gravel, or supported by piles, the river will scour around the front sides and nose of the channel piers, and I, therefore, uniformly make it a habit to riprap clear around each and every one of the piers, built within the ordinary navigable limits of the river.

In studying over the soundings and the specifications for pile driving for the Peoria Bridge, my experience leads me to believe that it was, to say the least, an extremely hazardous thing to attempt to drive wooden piles, such as specified, to rock, as the chances (verified in the excavation for the abutments) are that to attempt to drive a pile through such material, and to such a depth, is almost sure to fracture a large percentage of the piles after the first few have been driven and the foundation begins to peck.

Contractors proverbially place the sheeting too close to the finished work for their own economy, and even in this case if it were placed well without the finished work. I very seriously question whether it would have prevented the foundations from scouring to the danger limit. Basing my calculations upon the facts before me, I firmly believe that all the scour mentioned could have been prevented by the intelligent placing of a few thousand yards of derrick size riprap, extending 15 to 20 ft. around the nose and front sides, and 10 to 15 ft. around the balance of the piers and abutments. I am satisfied that even if the cofferdams had been built and left in place, as specified, the protection against scour was wholly inadequate.

Signed,

E. K. Morse, M. Am. Soc. C. E.
Commonwealth Bldg., 308-316 Fourth Ave., Pittsburg, Pa., May 15, 1909.

The Engineer's Compensation and His Attitude Toward the Profession.

Sir: Permit me to hail with delight the creation of the Technical League. It is about time that the engineering profession, especially the younger members of it, bethought themselves and got down to doing something for themselves.

We can expect very little encouragement from the generals of the profession who are mainly responsible for the conditions in which the young engineers find themselves. The generals of the profession are much too busily engaged in reducing what is supposed to be a liberal profession to the status of a trade. They continually are devising schemes whereby the services of the engineer can be measured by the number of hours and minutes actually at work, and paid accordingly.

The amount of dignity that is accorded the young engineer may be seen by stepping into any large engineering office, even of so rich a corporation as the City of New York, and seeing how engineers, who have spent years and money to acquire a liberal training in the profession, and who are presumably engaged in a gentleman's occupation, are herded together as thick as the size of the room will permit with no other accommodations than a rough table or a part of it, a stool, and a drawer. What opinion can an outsider have of the dignity of the profession viewing such an inspiring sight, perhaps set off by the sight of a minor clerk or bookkeeper who is allowed more room and convenience than the engineer? What amount of dignity as an engineer can be stimulated

in the young graduate who steps into an office of that kind? And what wonder if the position of the clerk or bookkeeper is beginning to look to him more dignified than his own?

Is it so because the work of the engineer is not of so much importance or value? Not at all. The fault lies mostly with the engineer in charge who is more often than not a member of the Am. Soc. C. E., who, his membership notwithstanding, generally exhibits less respect for the individuality of the young engineer than for that of a mechanic who has the manhood to tell him what he should be paid and how many hours he is to work.

It is often stated that a skilled mechanic receiving his union wages reaches the limit of his opportunities, and that an engineer is not so limited and has more to look forward to. Granted. But we ought to be able to claim more than mere looking forward to. The proportion of adequately paid engineers to the total number engaged in the profession is so small that, unless he be a genius, his opportunities for earning a comfortable salary even at middle age may be considered extremely limited.

By all means let us have the Technical League and what it stands for. Let us no longer disguise our poverty under a mask of dignity. Let us work to raise the compensation and standing of the profession, and dignity will come with it. Respectfully,

"Young Engineer."

New York City, May 3, 1909.

Sir: I am inclined to believe that the apprehension of a vitiation of the high standard of character set for the engineering profession, by the inclusion in its ranks of unworthy members, is unduly magnified in the minds of some of your correspondents.

If a "quack" engineer is occasionally employed by an ignorant municipal body, the evil carries its own remedy by proclaiming itself to the world in evil results. If a corrupt municipal body knowingly employs such a man, no remedy is suggested.

During a period of over 40 years of active practice in the profession, the writer has formed some well-defined ideas regarding its general status, moral and intellectual.

It may be said with confidence that the whole body of engineers in the United States, both civil and military, occupies a unique position in the estimation of the public at large, and enjoys a reputation for maintaining the highest standards of integrity of character which is not shared in equal degree by any of the other "learned professions." This has come about in obedience to a certain "law of necessity." From the necessities of the case the engineer must be intrusted with enormous interests, financial and other; and also in the nature of things he is peculiarly free from the control of his employers in the disposition of such interests. If the engineer is a dishonest man he can indulge in speculations and so cover his tracks as to make specific detection impossible. These conditions are unavoidable; hence by the action of a law of necessity an irreproachable standard of integrity has resulted; otherwise there could be no *modus vivendi* for carrying on the great business enterprises of the country which require the guidance and control of the engineer.

Another reflection here presents itself; the engineer has no use for error or untruth in his mental workshop; he is continually engaged in searching for errors, and as soon as discovered they are cast out. This engenders a certain habit of thought along lines of verity, which leads the mind to recoil from untruth as a primal impulse, and the mentality of the engineer is shaped in such a mold, by automatic process.

An engineer who has any twists and kinks in his moral fiber can no more conceal the fact from discerning eyes than can a woman conceal for long the loss of virtue. A crooked engineer, however, adroit he may be in covering his crookedness, cannot avoid generating about himself a subtile atmosphere of suspicion which proclaims itself unmistakably to the perception of other engineers; and while perhaps no specific act of wrong doing can be detected, still he falls under the ban of disapproval in the estimation of those who are in association with him. Such a man cannot long remain in good standing in the profession, and though no word may be spoken directly in condemnation, he is silently elbowed out of the stream, and is to be found among the drift along the shore. If an engineer is asked by another his rating of such a man, while he may utter no word against him, the tone he uses, together with what he fails to say in commendation, usually has all the weight of direct condemnation.

Verily, the unsullied page of the character of "Caesar's wife" was not more sensitive to imputation of wrong than is the character of the engineer.

As regards the compensation which engineers receive for their services, compared with that of other professional men, the writer has heard an apt illustration of the matter thus stated; when approaching a strange town, to the best houses you see you may assign the lawyers; the next best are occupied by the doctors; and if there be any engineers in the town they are to be found in the boarding houses. Respectfully,

T. G. Dabney.

Clarksdale, Miss., May 7, 1909.

[On account of lack of space we cannot publish all of the large number of letters on this subject that we have received. We have selected the above two as typical of the two kinds of opinions which all these letters express. Both recognize the present low rate of compensation the profession now commands, but while one advocates the formation of a mutually beneficial engineers' labor union, in form if not in name, the other holds that improvement can only come through the efforts of individuals bound together by something more elevating than mutual protection against overbearing superiors. On the face of it, the former is the more tangible, but investigation will show that the advocates of the labor union idea have little but the most general views as to the methods which they propose, and that the benefits to be derived from the plan are most superficial.

Many of the letters make reference to the doctors' and lawyers' associations which, it is claimed, have done much to control and standardize their respective professions. Such societies are analogous to the great engineering societies in their discussions of the technical problems of their members, but differ in the point at issue. Doctors and lawyers are almost invariably independent operators; they neither hire nor are hired by their colleagues. Engineers, on the contrary, in their early years always, and sometimes all their life, are in the employ of other engineers, and this brings up the eternally disturbing relation of master and servant. This relation has engendered the wish for the unionizing of the profession. The men on the lower rungs of the ladder feel that they cannot get the proper recognition in the higher class of societies because such societies are always managed by the employing class, so they propose a union of their own which will force recognition.

Undoubtedly such a union, rightly organized, will have an immediate beneficial effect on the wages and conditions of the subordinates, but in its final working it will be most detrimental. Few members of labor unions ever rise above the level of their associates; in fact, the one apparent effect of the labor union is to establish a level above which few rise and below which none are allowed to sink. If the young engineer, dissatisfied with the "generals" of his profession (a tendency in young engineers most vividly shown in the batch of letters to this office in the past few weeks)—if such a subordinate ever expects to become a commander, he will hardly join a society the end of which will be the establishment of a lower grade of engineers, where the salaries, to be sure, will be higher than in the lower grades now, but whose members must remain at this slightly elevated level with small hope of advance. This prospect may seem far-fetched to the enthusiastic, but it is the history of the labor union and, in so far as the secrecy of membership and plans will allow prediction, to the labor-union class the only organization so far established must be assigned.

In order that the engineer may not conclude that his is the only "poorest paid profession in the world" we reprint herewith a recent letter to the Chicago "Daily Tribune":

To the Editor of the "Tribune."

Sir: Will some paper or magazine speak to the young men of the country who are seeking their life's work? Tell them the conditions in the professions.

The average income of the minister is $800. The lawyer barely makes $1,000, and must supplement his law business with outside interests. The doctor that clears $1,000 a year is among the few.

Whereas there should be one doctor to a population of 1,000 in the United States there is one to 572 people. The result is over-competition, less fraternal spirit, a lowering of ethics, a lowering of respect on the part of the people for the profession, hardships and privations for family life.

It would be a good idea for the next five years to convert the theological, law, and medical schools into agricultural colleges. Let our young men develop the resources of our broad and still new country. Let them enrich their country and themselves by producing and developing. They do neither at present by entering the professions.

A Doctor-Farmer's Wife.

—Ed.]

Clearing Ice from the Niagara Gorge R. R.

Sir: Accompanying this letter are [illegible] views taken Tuesday, April 27, showing the work [illegible] clearing the Gorge R. R. in the Niagara Canon. [illegible] 1 is about two miles below the whirlpool and show[illegible]hat is known as the Giant Rock, so familiar in the [illegible]lished photographs of the Gorge Route. Fig. 2 [illegible] Devil's Hole, about four miles down [illegible]m from the whirlpool. These pictures are in that [illegible] of the road which was overlaid to the greatest de[illegible] with ice and which presented to the onlooker from [illegible] opposite side of the river the appearance of greatest [illegible]aster to the railroad.

Of course the overhead work in this [illegible]ion was totally wrecked but our superintendent re[illegible]d practically all of the feeder cables and the trolley w[illegible]. After the first flooding there were two distinct ice [illegible]ms with an interval of about one week between them during which time the tracks had been nearly cleared of the first deposit of ice. After the subsidence of the waters in the first instance the roadbed was found to be absolutely unharmed and only at points where the ice failed to lodge were the tracks disturbed at all.

After the formation of the second dam, which was much higher than the first, the tracks were broken over the double culvert about a mile up stream from the Suspension Bridge. Here the timber stringers which supported the tracks over two 14-ft. openings by their buoyancy helped to lift the rails and caught in a great swirling eddy, twisted and broke the connections. At no other point was any more serious damage done than throwing the tracks out of line and washing away part of the shoulder for short distances.

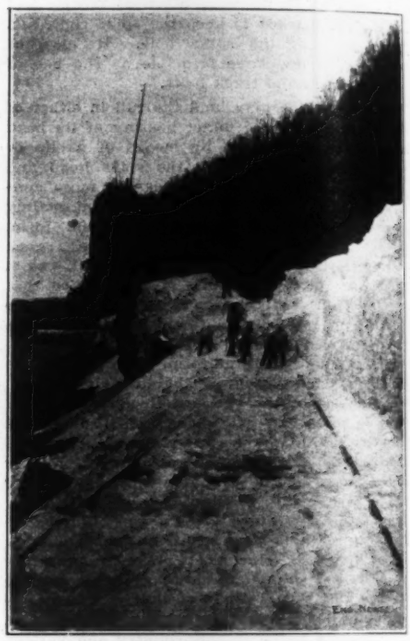


Fig. 1. Niagara Gorge R. R. Clearing Ice Away April 27.

Where the railroad is not built upon a solid shelf or ledge of rock the embankment is made of loose rock borrowed from the talus and the flooding of such a bank did no harm whatever, as upon the recession of the waters, there was no flowing out of soft material, although the roadbed was saturated. For nearly the entire distance of such construction heavy dry walls have been constructed or the banks protected by riprapping with stone weighing from three to five tons each. This method of protection has been found entirely practicable and proved to be most efficient in resisting the action of the heavy cross currents of the rapids. A flat car equipped with a hoist and powerful motor has been kept in service for several years in constructing dry walls and riprapping such as I have described.

Most of the poles which were carried away were old and were about to be replaced; indeed three carloads of new poles arrived just before the ice jam.

In the views the third rail, which is shown on the outside, is a continuous guard rail along the entire track. It stands 5 ins. above the outer bearing rail and is supported on every fourth tie upon chairs. It will be noted that in these photographs, which fairly show the condition found throughout the length of the road below the whirlpool, that the track is not out of line or disturbed in any way. As the waters receded the great weight of ice settled down upon the tracks and held them securely in position and really acted as

a protection [illegible] roadbed. None of the steel trestles or bridges [illegible] ured at all.

The gr[illegible] ense to which the company will be subjected [illegible] e putting up of overhead work. The repairs to [illegible] is are unimportant and with the exception of [illegible] eak in the track above referred to the work will [illegible] ly the resurfacing and realining. That this railr[illegible] ould have been subjected to such an extraordinar[illegible] and come out of it without being seriously da[illegible] is conclusive proof of its most substantial [illegible] nstruction. A few weeks will suffice to put everything [illegible] in good order again and with favorable weather [illegible] itions regular operation may be resumed the first [illegible] June.

Yours very truly,

George A. Ricker,

Chief Engineer Niagara Gorge R. R.

702 Elliott Sq., Buffalo, N. Y., May 8, 1909.

Since the above letter was set up in type we have received the following additional information from Mr. Ricker:

May 14, 1909.

Regular operation is going on now from Niagara Falls to the Whirlpool, both tracks being in excellent condition. To the Giant Rock, some two miles below the Whirlpool, the double track is cleared of ice and has been lined up and resurfaced. From the Giant Rock to a point just below the Devil's Hole the outside track is cleared and in good condition. From the last point to Lewiston the men are at work. From the Giant Rock to Lewiston the ice still covers the inside track to a depth of from 6 to 10 ft. Operation of the road will be resumed on the 23d or 24th of this month.

FIG. 2. NIAGARA GORGE, APRIL 27; FOUR MILES BELOW WHIRLPOOL.

The Mineral Analysis of Water for Industrial Purposes.

Sir: We are much interested in South Australia in the softening of water and otherwise rendering it suitable for use in locomotives.

I referred the paper printed in your issue of Oct. 1, 1908, to the South Australian Government Analyst, and the result is the attached letter, which I forward, with the short paper written by Mr. Hargreaves, for your information.

I am, Dear Sir, yours faithfully,

Alex. B. Moncrieff,

Engineer-in-Chief, South Australia.

Adelaide, Dec. 31, 1908.

[Mr. Hargreaves' letter follows.—Ed.]

MEMORANDUM FOR THE ENGINEER-IN-CHIEF.

The paper on "Mineral Analysis of Water for Industrial Purposes," by Herman Stabler, in the Engineering News for Oct. 1, 1908, forwarded for my perusal, contains many matters of interest to analysts as well as engineers. The adoption of the ionic theory in the statement of results of analysis has something in its favor as against the older methods. There are, however, many objections to its use in the way advocated by Mr. Stabler, and assumptions have to be made which are just as unwarranted as those that are required in stating the results of analysis in the form of salts. We do not know, for instance, that all the chlorine in solution is in the ionic condition, and the way in which the chlorine is combined makes a considerable difference,—thus a solution of magnesium chloride is certainly more harmful to a boiler than a solution of sodium chloride. The statement of results in the form of salts as calculated from the analytical data shows the relative proportions of the elements in a manner much clearer than that proposed in the paper under review.

The standards suggested by Mr. Stabler are of some assistance, but they must not be taken too literally. For example, when judged by these standards, practically all our South Australian reservoir waters would be classed as "foaming," whereas most of them are successfully used in locomotives without trouble in this respect. It has to be remembered that the analysis shows not the salts in the water, but attempts to show rather the composition of the total solids. The author of the paper advocates the statement of results in parts per million, but it is for many reasons more useful to express results in parts per hundred thousand (i. e., milligrammes per 100 c.c.), one reason being that this is the form in which results of analysis are usually obtained. So long as our present system of weights and measures is in vogue, the practical engineer will, I think, prefer the figures to be stated in grains per gallon.

In many ways the method of analysis devised by me and set out in the paper attached hereto, is simpler than that proposed by Mr. Stabler and gives as much, if not more, information.

W. A. Hargreaves,

Government Analyst and Inspector of Explosives, South Australia.

Adelaide, Dec. 24, 1908.

[Mr. Hargreaves' paper is reprinted elsewhere in this issue. Proof of both the paper and the foregoing letter were submitted to Mr. Stabler. Comments from him follow.—Ed.]

Sir: An analysis of water for boiler use is of value to the engineer only in so far as it will enable him to forecast the probable effect of the water when used in boilers, to calculate the proper doses for purification, and to compare probable effects and costs of treatment of different waters. No matter what method of analysis is used or what method of expressing the results of analysis is employed, interpretation with respect to costs of treatment and probable effects of use must be made before the analytical results can be of value, and the more definite such interpretation can be made, the greater will be its value. In brief, the analysis is a basket, but the interpretation is its handle. Schemes for the interpretation of analyses calculated to hypothetical combinations are abundant and are reasonably satisfactory. My article in your issue of Oct. 1, 1908, was devoted entirely to the interpretation of analyses expressed in ionic form in parts per million, a mode of expression for which heretofore, so far as I am aware, no scheme of interpretation has been put forward. I did not advocate this or any form of analytical statement, but merely attempted to fit a good handle to a handleless basket. Mr. Hargreaves, therefore, seems to have missed the main point of my article. There are a few points, however, upon which I would like to comment.

(1) I am glad to receive the criticism on the proposed standards of foaming, for it is only in this way that our standards can be improved. My proposed formulas are admittedly poor, for in addition to the neglect of suspended and organic matter they omit the most important consideration of all, boiler operation. Were the boiler practice of New England applied to South Australian waters, I am inclined to believe that trouble from foaming would result.

(2) With regard to the various forms used in reporting analyses, the lack of uniformity between parts per million, grains per Imperial gallon, grains per U. S. gallon, and parts per hundred thousand is least confusing, for changes from one to the other can be made by the use of simple equivalents applied to the entire analysis. The disagreement between the ionic form and the several forms using hypothetical combinations is not so easily reconciled. The ionic form does not, as Mr. Hargreaves seems to think, imply that the substances are present as ions not in combination. It is merely a statement of the analytical data and has no reference to the condition of substances it enumerates. This is to my mind its greatest value to the user of water analyses. A thousand chemists working on the same water sample and using different methods of analysis would attain results, differing only within narrow limits when expressed in ionic form, for they then deal with facts alone. Now let them enter the realm of fancy, and, as Mr. Hargreaves expresses it,

> calculate the composition of the total solids upon some assumption as to the preference of certain basic ions for certain acid ions.

The results are sent out as actual analyses, whereas they are merely statements of assumptions. Even so, were it possible for chemists to agree on their assumptions we engineers who try to use their results could get along very nicely. But with the present lack of unanimity the thousand chemists might send in fifty different forms of statement. For example, the simple analysis cited by Mr. Hargreaves might appear in the following forms, each of which would have its staunch adherents in this country. (By Mr. Hargreaves' special method of analysis the third of these forms would not be admissible.)

(Grains per Imperial gallon.)

	(1)	(2)	(3)
$CaCO_3$	12.0	0.0	0.0
$MgCO_3$	5.9	16.1	0.0
Na_2CO_3	0.0	0.0	20.2
$CaCl_2$	0.0	0.0	0.0
$CaSO_4$	0.0	16.3	16.3
$MgCl_2$	2.7	2.7	21.0
$MgSO_4$	14.6	0.1	0.1
Na_2SO_4	0.0	0.0	0.0
NaCl	69.6	69.6	47.2

When looking at these parallel columns we can readily see why Dr. F. W. Clarke, one of the foremost chemists of America, refers to a statement of such combinations as "a meaningless chaos of assumptions and uncertainties." Without entering into this war of the chemists it is probably sufficiently evident that such statements, while possibly answering the purposes of a chemist or a small group of chemists, render extremely difficult the work of the man who attempts to correlate the work of many chemists of diverse schools, and necessitates the use of a separate scheme of interpretation for each set of assumptions.

(3) Mr. Hargreaves states

> the way in which chlorine is combined makes a considerable difference—thus a solution of magnesium chloride is certainly more harmful to a boiler than a solution of sodium chloride.

The latter part of this statement is freely granted. The chlorine is the same with the same properties in each, however, and the difference in regard to injurious effects must be charged to the difference between the properties of magnesium and sodium ions. This is fully taken into account in the formulas I presented. So long as $MgCl_2$ remains $MgCl_2$ it will do no harm. To conceive of injury to the boiler, the chemist must assume that the magnesium chloride is broken up. Is it not unnecessary, then, to assume that it has existed as such, or to express it as an integral part of the analytical statement? Furthermore, how can we judge correctly from combinations when they may be so diverse as those tabulated above? Shall we measure the probable ill effects of magnesium chloride by the 2.7 grains shown in forms (1) and (2) or by the 21.0 grains shown in form (3)?

(4) Mr. Hargreaves presents a scheme of analysis not materially different from some of the partial-analysis methods for rapid approximate work used in this country. The scheme omits several determinations which are at times very important, but it undoubtedly serves a very useful purpose. I note with interest that the ionic form is used for calculating cost of treatment and is maintained up to the final step of calculation to combinations. The calculation of all determinations to $CaCO_3$ is similar in effect to the reacting value scheme and the results so expressed can readily be used in my formulas. Dividing each of his determinations by 3.5, the following equivalents result: RCO_3 = Ht, RCa = Hca, RMg = Hmg, $RHCO_3$ = A-Ht, RCl = Cl, RSO_4 = SO_4, and RNa can be found as the difference between the sums of reacting values of positive and negative ions. Reduced to the limits of the partial analysis my formulas are:

Lime	= .26 (RMg + $RHCO_3$)
Soda ash	= .465 (RCa + RMg − $RHCO_3$)
F	= 2.7 Na
C	= RMg + $RHCO_3$
S	= .168 RMg + .492 RCa
HS	= .168 RMg + .567 RCa

With about two minutes calculation the following would result: For treatment, 3.0 lbs. 90% lime and 2.0 lbs. 95% soda ash per 1,000 U. S. gallons, costing about 3.3 cts.; and the classification, (1,050) foaming, (+86) corrosive, (2.74) much (1.09) hard scale. The words of this classification indicate clearly the probable effects of the water when used in a boiler and the numbers form a satisfactory basis for comparison with other waters. Such a comparison can not be made directly from hypothetical combinations, even if the same assumptions be made in computing the various statements compared.

Possibly, as Mr. Hargreaves says, his statement of combinations gives as much, if not more, information than an ionic statement of the analytical data supplemented by the foregoing classification, but I am inclined to believe otherwise.

Yours truly,

Herman Stabler.

U. S. Reclamation Service, Washington, D. C., April 8, 1909.

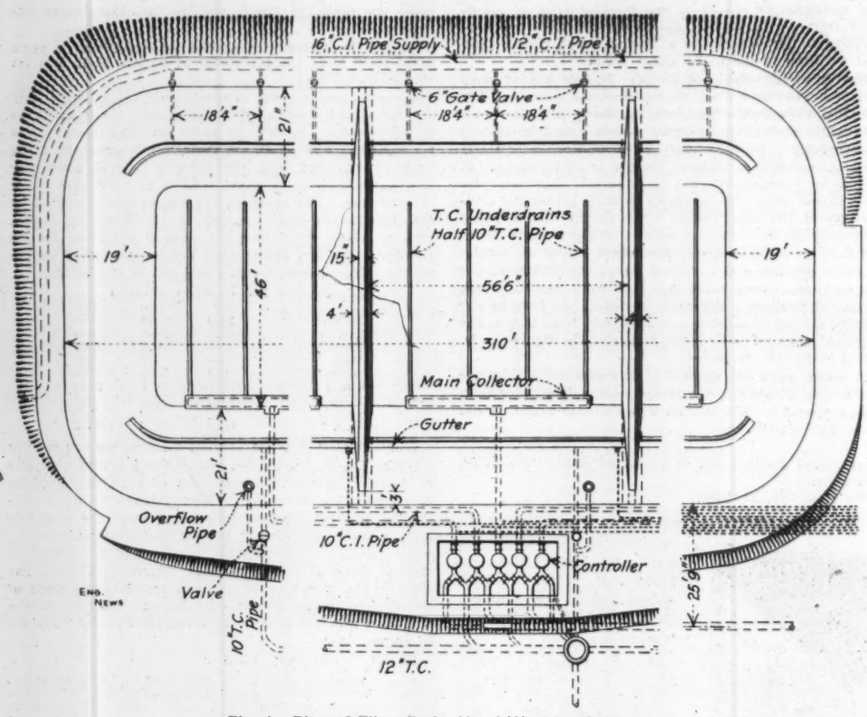


Fig. 1. Plan of Filter Beds, Hand-Washing Scheme.

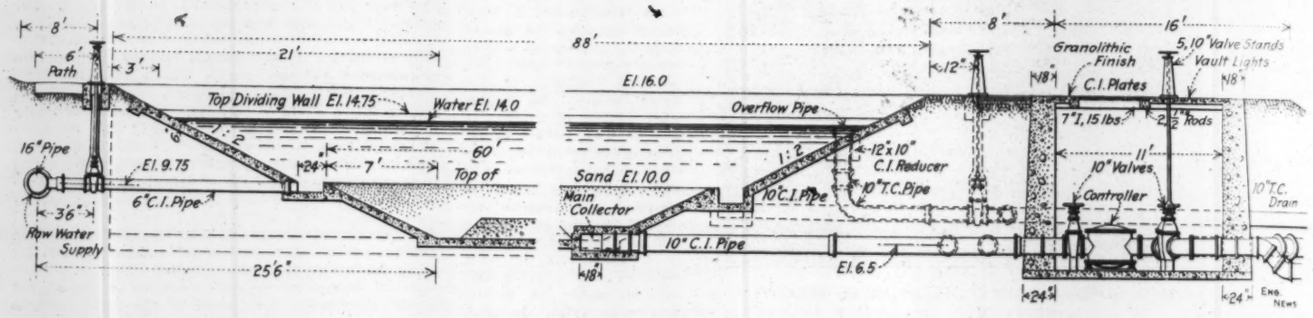


Fig. 3. Cross-Section of Beds, Arranged for Hand Washing.

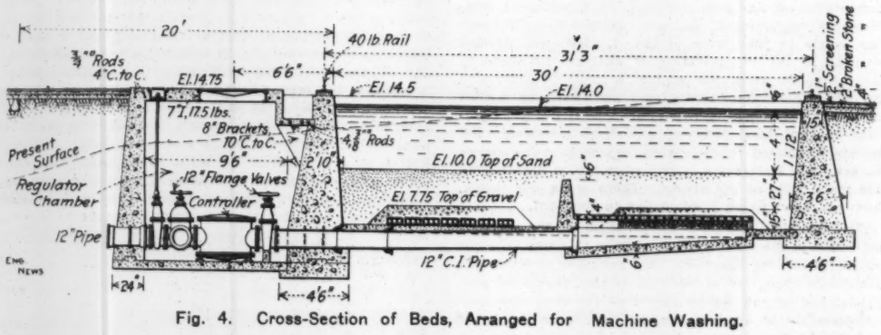


Fig. 4. Cross-Section of Beds, Arranged for Machine Washing.

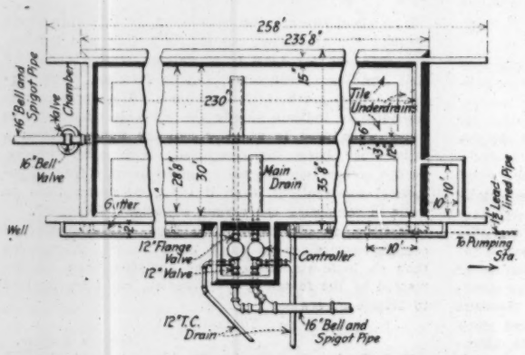


Fig 2. Plan of Filter Beds, Machine-Washing Scheme.

FIGS. 1 TO 4. ALTERNATIVE DESIGNS FOR A WATER FILTRATION PLANT AT BAYSIDE PUMPING STATION, BOROUGH OF QUEENS, NEW YORK CITY.

Alternative Designs for Hand-Washed and Machine-Washed Slow-Sand Water Filters, Borough of Queens, New York City.*

Among the measures proposed by Mr. I. M. de Varona, M. Am. Soc. C. E., Chief Engineer of the Department of Water Supply, Gas and Electricity, New York, to relieve the shortage of water in the Borough of Queens, and as one from which the quickest and surest results might be expected, he recommended, on March 7, 1907, to the Commissioner of the Department, the utilization of the waters of Oakland Lake, near the Bayside pumping station, in the Third Ward, Borough of Queens, by filtering the waters from the lake, which, in their present condition could not be safely used. Mr. de Varona had for a long time before made a similar recommendation, but no action had been taken, and he urged that under existing conditions, this work should not be delayed.

After discussing and considering the purification of the water by ozone, in accordance with propositions received for that purpose, two plans were prepared for the filtration plant and submitted on the date referred to; supplemented afterwards by plans for deep driven wells, following tests made for that purpose at Bayside. Plans were also prepared for additional engines and remodeling of the Bayside pumping station. In his official report, Mr. de Varona stated that the work outlined could be completed, after beginning work, as follows: Filtration plant, within four months, enlargement of buildings and well, within six months; additional wells, cleaning, etc., within eight months, and engines, within ten months or one year; so that the additional supply, if prompt action were taken, could be made available towards the end of 1907 and certainly not later than the middle of 1908. Unfortunately, the appropriation for the work was not granted until Feb. 11, 1908, and under the condemnation proceedings instituted since, the city has not yet obtained actual possession of the land, although it is now confidently expected that possession will be secured within a very few days. As the contracts and specifications for the works have all been completed by the chief engineer of the department, and, in fact, all of them are actually printed, these contracts will be immediately advertised by the commissioner of the department, so that it is expected that the additional water-supply from these works will be available in a few months. This additional supply is estimated at from 2,000,000 to 2,500,000 gals. per day, and its relative importance may be gaged from the fact that the average daily yield of the Bayside station in 1908 was only 1,380,000 gals.

Oakland Lake is situated about one mile east of Bayside, Long Island, and has an area of 17 acres and a drainage of 1.8 square miles. Gagings made in 1906 and 1907 show a probable daily yield of 1,500,000 gals. and that is the capacity of the filters as designed.

The usual method of slow-sand filtration has been adopted and two plans prepared, the choice of which will be made after the receipt of bids.

*Information supplied through the courtesy of Mr. I. M. de Varona, Chief Engineer Department of Water Supply, Gas and Electricity, Park Row Building, New York City.

Under either of plans the filters would be cleaned by the Long Island method, as developed by the Department of Water Supply, Gas and Electricity under I. M. de Varona, while Chief Engineer in Brooklyn, at the Hempstead and Forest Stream plants (see Eng. News, Aug. 23, 1906) and subsequently used at the Jerome Park Experimental Station.

Under the second plan the beds are to be cleaned by machines, as manufactured by the Blaisdell Filtration Co. This machine has been in operation at Yuma, Ariz., for some years, and one of them was tested at the experimental station installed by the Department of Water Supply, Gas and Electricity at the Jerome Park Reservoir, in 1906 and 1907 (see Eng. News, March 12, 1908).

Under either method of cleaning the time that a filter bed is out of service, while cleaning, is shortened and an increased rate of filtration is economical, a fact which has been taken into account in the plans designed.

In both designs, the filters will be contained in open concrete basins, and the influent will reach the filters through a 16-in. cast-iron pipe, suitably gated, while the effluent, after passing the rate controller, will be collected in a 16-in. cast-iron line and conducted 350 ft. to the Bayside pumping station, where also will be located the necessary recording and indicating apparatus.

HAND-WASHING OR LONG ISLAND CLEANING METHOD.—Each of the five filters (Figs. 1 and 3) will have an area at the sand line of 3,300 sq. ft., or a total area of 16,500 sq. ft. The rate of filtration for all five beds which may be operated practically continuously, will therefore be 4,000,000 gals. per acre per day.

The underdrains will be of 10-in. terra cotta pipe, split longitudinally, four lines to a bed, joining a concrete main collector. This, in turn, delivers through a 10-in. cast-iron pipe to the controller. A study of the regulator chamber shows that the effluent from any filter may be wasted if so desired. The underdrains are surrounded with 16 ins. of gravel, graded in size, supporting 26 ins. of filter sand, the effective size of which is to be within the limits of 0.27 mm. and 0.33 mm. and the uniformity coefficient 1.85. Normally there will be 4 ft. of water over the sand.

The process of cleaning may be described as follows: The sand bed, of the usual construction, has a trough at one end set at the sand level for the even distribution of a small quantity of raw water and at the other end a similar gutter is provided to collect this water. In cleaning, the water on the beds is drawn down until the sand is covered barely 2 ins., and water is then applied through the trough and flows to the gutter, while men with rakes or stable brooms break up the schmutzdecke. The dirt is thus suspended in the flowing water and is carried from the bed, the process being continued until the water in the gutter runs clear. The wash water required is about 0.5% of the filtrate, figured on a yield [between cleanings] of 30,000,000 gals. The advantages of this process, which obviously can be improved as regards the method of raking, are as follows:

(1) Time saved in drawing the water below the sand surface, backfilling to sand surface and actual time of cleaning.

(2) The sand has not to be taken from the bed, washed, stored and later restored.

(3) The sand bed is not drained; therefore, when a filter is operated under a positive head only, air does not collect in the sand voids, so that there is reason to believe that the nominal rate becomes, in fact, an actual one.

As a consequence, the excess area of the plant may be materially reduced and the expense both of installation and subsequent labor charges reduced.

MACHINE CLEANING METHOD.—The filter is divided longitudinally into two beds (Figs. 2 and 4) of equal size by a wall extending from the bottom to within 6 ins. of the sand surface, but the space above is undivided. This is made possible by the fact that the machine in cleaning disturbs only the sand being treated, which cleaning takes place without drawing the raw water from the bed. The sand surface area is 6,700 sq. ft., making the rate of filtration approximately 10,000,000 gals. per acre per day.

The underdrains are of vitrified clay "cable ducts," 3¼ ins. interior diameter, covering practically the entire filter bottom and discharging into a concrete main collector, connected by a 12-in. cast-iron pipe to the controller.

The ducts shall be of the best quality, sound, hand-burned, salt-glazed, vitrified clay, with surfaces smooth, hard and even of uniform texture, free from blisters, cracks, flaws and any imperfections and shall be acceptable in every respect. The ducts shall be true in shape or form and straight, or of the required curvature and the ends shall be cut at right angles to the axis of the pipe.

The conduits shall be equal in serviceability to those shown on the plans, which are of the multiple type, with three ducts each, and each opening shall be uniform in cross-section, so that with the adjoining ducts, there will be a smooth and uniform space, not less than 3⅛ ins. in diameter. Each duct shall be separated from the one adjoining lengthways by two steel dowel pins, on which has been placed a molded cement separator, ⅝ to ½-in. thick.

Immediately before placing the terra cotta underdrains, the contractor shall thoroughly clean the floors and walls of each filter, so that they may be free from foreign matter of any kind.

The ducts shall be laid in straight parallel lines with open joints, so that there will be a space between them equal to the thickness of the molded cement separators. There shall be no space between adjoining rows of ducts. The joint between the ends of the ducts in any row shall come opposite the middle of the ducts in the adjoining rows. The ducts shall be laid as soon as practicable after the concrete bottom of the filters is set. A finishing course of cement mortar about ½-in. thick shall be spread over the concrete surface, trowelled smooth and then before the mortar coating has set, the ducts shall be placed in their final position bedded slightly in the mortar. The joints shall be left free and open and all mortar droppings shall at once be removed from the floor. Any ducts which become displaced before the completion of the work by whatever cause, shall be replaced in a satisfactory manner, so that the bottom of the filters shall be smooth and uniform under and around the ducts laid in the manner above specified.

The underdrains are surrounded with 15 ins. of graded gravel, supporting 27 ins. of filter sand, as specified above.

Rails of 40-lb. per yd. weight extend along the top of longitudinal walls, for the travel of the washing machine. The rails are extended at one end, so that the machine may be run over the adjustment pit, for changes in equipment.

The filtered water will be delivered into a covered well whence it will be pumped into the distribution system.

The plans, contracts and specifications for the work were prepared under the direction of Mr. I. M. de Varona, Chief Engineer of the Department of Water Supply, at the Manhattan office, and those for the filter plants were under the immediate charge of Mr. William B. Fuller, of the Filtration Division, and were approved by the consulting engineers, Messrs. George W. Fuller and Rudolph Hering.

The Technical Examination of Boiler Waters.*

By W. A. HARGREAVES, M. A., F. I. C., and W. T. ROWE.

The quantity of literature upon this subject is so great that some apology would seem necessary for further increasing it, but it is chiefly on account of this very abundance that it is advisable now and again to attempt to compile brief methods embodying the results of the researches of others. No originality is therefore claimed for any of the details about to be set out, nor even for the general principles contained in the method. All that we state is that a working scheme has been evolved, based on the suggestions of others too numerous to individually acknowledge, which appears, so far as our experience goes, to be an improvement on any methods that we have seen published.

In this country, where so many raw waters previously untested or analyzed have to be taken into use, much of the work of the analyst is of a pioneering nature, and it is necessary that he should make a large number of rapid examinations rather than detailed analyses of a few samples made with the greatest accuracy possible.

The following scheme will be found to permit of these fairly rapid examinations being made with an accuracy very closely approximating to that given by a detailed analysis by ordinary methods.

SCHEME FOR ANALYSIS OF SALTS IN BOILER WATERS.

Determine the following:

(1) ALKALINITY (= A), by titrating 70c.c. of the sample with N/10 HCl. and methyl orange.—Let a c.c be required.

Then A (i. e., alkalinity) = 5a.
= Ht. + Na_2CO_3 (in terms of $CaCO_3$).
= total CO_2 (in terms of $CaCO_3$).

(2) PERMANENT HARDNESS (= Hp).—Boil 70c.c. of the water with considerable excess (i. e., at least 30c.c. in one and 40c.c. in the duplicate) of N/10 Na_2CO_3 for half an hour (or until reduced to small bulk), filter while hot, wash three times (not more) with boiled hot distilled water, titrate filtrate with N/10 HCl. and methyl orange.

Let N be the quantity of N/10 Na_2CO_3 taken, and n c.c. N/10 HCl. be used in the titration. Then Hp = 5 (N — n) and Total Hardness = H = Hp + A (i. e., the algebraical sum) and Temporary Hardness = Ht = H — Hp.

If the water contains NA_2CO_3, the Hp. will be a minus quantity, and its amount represents the Na_2CO_3 in terms of $Ca.CO_3$. If the Hp is zero or a positive quantity, there is no Na_2CO_3 in the water, and then A = Ht.

(3) HARDNESS DUE TO CALCIUM (= Hca).—Boil 350c.c. of sample with few drops HNO_3; then add about 0.5 gramme of AmCl, make alkaline with ammonia, and boil; then add boiling solution of ammonium oxalate; filter; wash with boiling distilled water till free from oxalates; prick the filter; dissolve the ppt. with hot dilute H_2SO_4; boil solution, and titrate hot with $KMnO_4N/_{10}$ sol.

Let C be number of c.c.'s required.

Then Hca = C.

And hardness due to magnesium = Hmg = H — Hca.

(4) CHLORINE.—Determine in the usual way—by titrating 70c.c. of sample with standard $AgNO_3$ (4.7888 grammes per litre) and $K_2Cr_2O_7$.

Let S = number of c.c.'s required.

S × 1.408 = cl in terms $CaCO_3$ per gallon.*

(5) SULPHATES.—Determine as usual, by precipitation with $BaCl_2$, using 350c.c. of sample.

Mgms of $BaSO_4$ from 70c.c. of sample × 0.4285 = SO_4 in terms of $CaCO_3$ per gal.

(6) TOTAL SOLIDS.—Evaporate 70c.c. in platinum dish on asbestos pad over low flame burner to dryness; bake in air oven 150°C.

This is the whole of the laboratory work required for the calculation of the assumed composition of the total solids. For all practical purposes only determinations (1), (2) and (3) need be made, and from these three alone suitable treatment can be calculated thus:

(I.) Using CaO and Na_2CO_3—

1. 0.56 × (Ht + Hmg) = lbs. of real CaO required per 7,000 gals. of sample.
2. 1.06 × Hp = lbs. of real dry Na_2CO_3 required per 7,000 gals. of sample.

(II.) Using NaOH and Na_2CO_3—

1. 0.8 × (Ht + Hmg) = lbs. of NaOH required per 7,000 gals. of sample.
2. 1.06 × [Hp — (Ht + Hmg)] = lbs. of dry Na_2CO_3 required per 7,000 gals. of sample.

The treated water can be quickly examined by determinations (1), (2) and (3), and the water treatment readily controlled.

CALCULATION OF TOTAL SOLIDS.—For purposes of report or comparison with other analyses, it may be desirable to set out the composition of the salts. For this, determinations of (4), (5) and (6) are required in addition to the first three. Although the bases and acids are probably not combined as salts in the water, still it is usual to calculate the composition of the total solids upon some assumption as to the preference of certain basic ions for certain acid ions. Two assumptions present themselves, namely—either that the acid ions should be allotted to the basic ions in sequence (as chlorine to sodium, potassium, magnesium, and calcium in succession, then CO_3 and SO_4 allotted in turn), or else the basic ions are distributed to the acid ions in succession. For many reasons we adopt the latter, and the results seem more in accord with those shown by the method of analysis stated above.

Our ideas are concentrated by the following arrangement, with example taken from an actual case:

$CaCO_3$, $MgCO_3$, Na_2CO_3	= A = 19.....	In terms of $CaCO_3$ per gallon
Na_2CO_3	= (— Hp) = nil...	do.
$CaCO_3$, $MgCO_3$	= Ht = 19.....	do.
$CaCl_2$, $CaSO_4$, $MgCl_2$, $MgSO_4$	= Hp = 15	do.
$CaCo_3$, $CaCl_2$, $CaSo_4$	= Hca = 12.....	do.
$MgCo_3$, $MgCl_2$, $MgSo_4$	= Hmg = 22.....	do.
Total Hardness = H = 34....		do.
Chlorine = 62.38.....		do.
SO_4 = 12.14		do.
Total Solids = 113.2.....		do.

*A paper read at the Adelaide meeting of the Australasian Association for the Advancement of Science, held January, 1907. (Reference to this paper is made in letters by Mr. Moncrieff and Mr. Hargreaves, in our correspondence columns this week.—Ed.)

[*American readers should note that the gallon here used is the Imperial, of 70,000 grains.—Ed. Eng. News.]

TABLE OF CONVERSION FACTORS.

	Factor.	Logarithm.		Factor.	Logarithm.
$CaCO_3$ into $MgCO_3$	0.844	$\bar{1}.9263$	$MgCO_3$ into $CaCO_3$	1.1850	.0737
" " $CaSO_4$	1.360	.1335	$CaSO_4$ " "	0.7353	$\bar{1}.8665$
" " $CaCl_2$	1.110	.0453	$CaCl_2$ " "	0.9010	$\bar{1}.9547$
" " $MgSO_4$	1.204	.0806	$MgSO_4$ " "	0.8307	$\bar{1}.9194$
" " $MgCl_2$	0.954	$\bar{1}.9795$	$MgCl_2$ " "	1.0480	.0205
" " Na_2CO_3	1.060	.0253	Na_2CO_3 " "	0.9434	$\bar{1}.9747$
" " Ca	0.400	$\bar{1}.6021$	Ca " "	2.5000	.3979
" " Mg	0.244	$\bar{1}.3874$	Mg " "	4.0990	.6126
" " SO_4	0.960	$\bar{1}.9823$	SO_4 " "	1.0420	.0177
" " Cl_2	0.710	$\bar{1}.8513$	Cl_2 " "	1.4080	.1487
" " CO_2	0.600	1.7782	CO_2 " "	1.6660	.2217
" " 2NaCl	1.170	.0682	2NaCl " "	0.8547	$\bar{1}.9318$
" " $BaSO_4$	2.334	.3681	$BaSO_4$ " "	0.4285	$\bar{1}.6319$
" " Na_2SO_4	1.420	.1523	Na_2CO_4 " "	0.7042	$\bar{1}.8477$
$BaSO_4$ " SO_4	0.4115	$\bar{1}.6144$	SO_4 " $BaSO_4$	2.4300	.3856

All results are stated in equivalent terms of grains $CaCO_3$ per gallon, and this statement is maintained throughout the calculation until the final conversion to actual quantities is made. This method has the very great advantage of reducing the labor of the calculations to a minimum, most of the work consisting merely of subtraction and addition. Assuming then that the calcium combines first with the CO_2, then with SO_4 and lastly with chlorine, that magnesium combines with the acids in the same order, but following calcium, and that the alkali metals pursue an opposite order (except that we know whether Na_2CO_3 is present or absent), we note in the example that since the Hca is less than Ht, all Ca exists as $CaCO_3$, and there is no $CaCl_2$ or $CaSO_4$, and since the Hmg is greater than the SO_4, all the SO_4 is combined with Mg, and there is no Na_2SO_4.

We get, then, the following.

	Expressed in equivalent grains of $CaCO_3$ per gallon.	Actual quantities in grains per gallon.
$CaCO_3$	12.0	12.0
$MgCO_3$	7.0	5.91
Na_2CO_3	nil	nil
$CaCl_2$	nil	nil
$CaSO_4$	nil	nil
$MgCl_2$	2.86	2.73
$MgSO_4$	12.14	14.62
Na_2SO_4	nil	nil
NaCl	59.52	69.63

The conversion to actual quantities shown in the last column is made by using the factors shown in the table above.

As a check upon the method an analysis may be made by any of the older methods. So far as boiler waters are concerned, the crucial test is in the magnesium. In the example quoted the magnesium, as directly determined, was 5.31, while the result obtained by calculation from the Hmg = $22 \times .244 = 5.37$.

Notes.—In selecting this mode of analysis a large number of suggestions were experimented upon. For instance, the total hardness may be obtained directly by making the titration in determination 1 to exact neutrality, boiling off the CO_2, adding excess of $N/_{10}Na_2CO_3$, and continuing as in determination 2. In this case the total hardness = 5 (N — n). This may be used as a check on the other determinations. Again, it has been suggested to determine the Hmg directly by means of lime water; but this, and a scheme for treatment calculations based upon a lime factor in which lime water is used, failed to give satisfactory results in practice. These were not abandoned without regret, for they seemed very promising and appeared to further simplify the analysis.

Slight modifications in detail have been tested. The only ones, however, that we found equally as satisfactory as the method to which preference has been given are in determination (2). These modifications are:

(a) Boil 140c.c. of the water with considerable excess (i. e., at least 60c.c. in one and 80c.c. in the other) of $N/_{10}Na_2CO_3$, for half an hour (or until reduced to small bulk); cool, and transfer to 200c.c. flask and make to mark with cold recently boiled distilled water; mix thoroughly and filter through a dry filter, rejecting the first portion of filtrate; draw off 100c.c. of filtrate (= 70c.c. of original water) and titrate with $N/_{10}HCl$ and methyl orange. This method, although apparently quicker than the way chosen, in practice occupies much more time and attention. It is, however, somewhat more accurate, since if in determination (2) the ppt. is not washed free of Na_2CO_3, low results will be obtained, and if it is washed too much a sufficient amount of the precipitated carbonates will be dissolved to vitiate the results. If three and not more washings are made in following out determination (2), the results are practically correct. On account of the quicker and simpler work required, this way has been given the preference.

(b) The other modification is to use a mixture containing equal volumes of $N/_{10}NaOH$ and $N/_{10}Na_2CO_3$ ("soda reagent") in place of the $N/_{10}Na_2CO_3$. So far as our experience goes there is no practical advantage in this, provided a considerable excess of $N/_{10}Na_2CO_3$ is used in determination (2). This has been confirmed by Gardner & Lloyd (J. S. C. I., April, 1905).

If only a slight excess is used the $MgCO_3$ is not fully precipitated, and erroneous results are obtained. The "soda reagent" has apparently the advantage that it represents more nearly the action which will take place in the actual softening treatment of the water, but this in practice does not render the determination any more accurate. Careful tests made with both yielded agreeing results, so that either reagent may be used in determining the permanent hardness. Jena, or resistance glass vessels, should be used in this determination to reduce the action on the soda, and this is especially necessary in the case of the fixed "soda reagent" being used.

The method of analysis here outlined possesses many advantages over the older methods, in that a water can be tested with less labor, in less time, and at less cost of materials; and further than this—more practical information as to the character of the water is obtained than by the more usual method of determining the bases and acids independently and calculating the salts. The method is therefore worthy of attention by those who are called upon to make technical examinations of boiler waters.

THE ELEVEN LIDGERWOOD UNLOADERS in the Central Division [on the Panama Canal Work] during the month of March, unloaded a total of 3,332 trains composed of a total of 58,309 cars. Of this number, 1,613 trains composed of 27,421 cars, were unloaded by five unloaders at Tabernilla; 758 trains composed of 13,590 cars, were unloaded by three unloaders at Miraflores dumps, and 961 trains, composed of 17,298 cars, were unloaded by three unloaders at La Boca. As all the cars were of 20-yd. capacity, the material unloaded represented about 1,166,180 cu. yds.—"Canal Record," April 28.

An Automatic Grade-Crossing Gate.

By J. B. VAN BRUSSEL.*

An automatic grade-crossing gate on electric railways has recently been installed near Montreux on Lake Geneva at a cross of the Montreux-Bernese Electric Railway and is reported as working satisfactorily. A general appearance of the crossing and gate is shown in Fig. 1 and the details of the operating mechanism in Figs. 2 and 3.

The barrier itself is a long pole lying across the roadway. A vertical channel carries, on a cast-iron bracket, all the driving mechanism, including the motor and its resistance coils and rheostat. This motor drives a large gear-wheel fitted to a conical drum, with a spiral groove, for winding the cable. The end of the shaft serves as the suspension point for one end of the cable which passes around the pulley on the horizontal bar of the counterweight. Below and parallel to the axis of the drum is a spring brake.

The inner end of the barrier bar which carries the counterweight is made of channel-iron, while the barrier itself is of light creosoted pine. The counterweight is a cast-iron frame made to hold different iron weights for use with bars from 10 to 30 ft. in length. At the pivot of the bar is a drum on which is wound a cable which crosses the track over a set of pulleys and operates the swinging bar on the other side of the track. To protect the driving mechanism from the weather it is covered by a light housing which can be readily removed. Several incandescent lamps and an electric bell are placed on adjoining poles as visible and audible signals. The current for the bell, lights and motor is supplied through the contact of the bow trolley with an auxiliary wire paralleling the trolley wire. The length of this signal wire, of course, depends upon the usual speed of the train at the crossing in order to allow the apparatus to operate shortly in advance of the passage of the car.

FIG. 1. AUTOMATIC GRADE-CROSSING GATE ON THE MONTREUX-BERNESE RAILWAY, SWITZERLAND.

From Fig. 3 the method of operation will be clear. When the bow trolley of the locomotive or car comes in contact with the auxiliary wire closely paralleling the main trolley wire, the windings of the apparatus are connected to the line. The current starts the motor, lights the incandescent lamps and rings an electric alarm bell connected as shown. The motor is series

*Boite Postale 151. Brussels, Belgium.

wou... ...10-HP., running at 460 r. p. m. on 120 ... minimize the effect of variations in v... the line upon the motor speed and the ... losing the barrier, a shunt resist- ance ...ralleled with the armature winding. The ... are placed at each side of the grade cross... and serve at the same time as lights and ... ls. The electric bell is connected in the ... circuit in parallel with a resistance.

The ...eration of the bar requires about 20 seco... During this time the drum by its screw ...ead is displaced in the direction of the shaft ... and stops the braking action of the spring ...orking upon the rim of the gearwheel. Before ...e bar has completely reached the horizontal ...osition the cable mounts the conical part

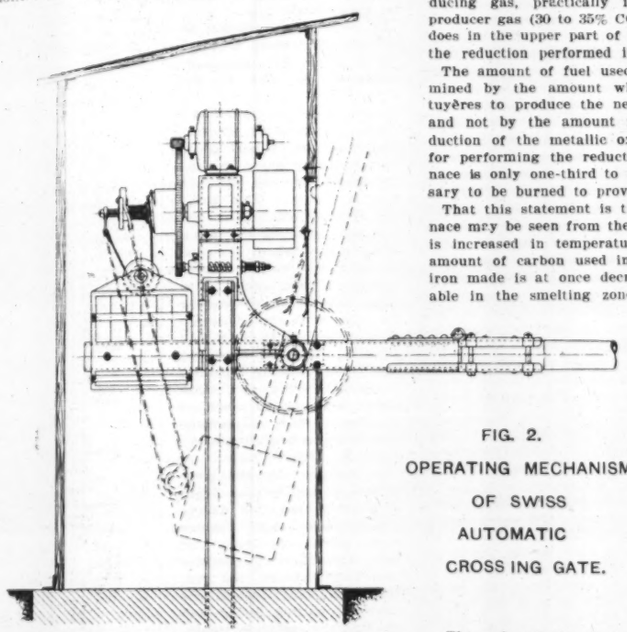


FIG. 2. OPERATING MECHANISM OF SWISS AUTOMATIC CROSSING GATE.

of the drum. As the torque exerted by the counterweight increases, the motor slows up and the bar is closed slowly at the end of its swing. When the counterweight torque balances the motor torque the bar remains closed with the current flowing through the motor when the trolley bow leaves the auxiliary wire. The counterweight acts to bring the bar back to the vertical position.

The Electric Furnace Reduction of Iron Ore.*

By JOSEPH W. RICHARDS.†

In order that one can understand thoroughly the problems arising in the reduction of iron ore by carbon in an electrically heated furnace, he should first of all have a clear idea of how this reduction proceeds in an ordinary, non-electrical blast furnace.

Blast Furnace Practice.

The iron ore contains iron oxide, with silica and clay as usual impurities, and more or less moisture; its phosphorus content may be low or high, but its sulphur content must be low, not over 0.5%. If the ore carries over 1% of sulphur it is given a preliminary roasting.

In the furnace, perhaps 99% of the iron oxide is reduced to metallic iron, 10 to 20% of the silica is reduced by carbon to silicon, which combines with the iron, all of the phosphorus is reduced into the pig iron, and a varying proportion of the sulphur, this proportion being smaller the more basic the slag is made with lime and the higher the running temperature.

Flux is added to make fusible slag by combining with the unreduced silica and the clay in the ore. Limestone, unburnt, is the usual flux, but magnesian limestone, carrying $MgCO_3$, is quite commonly used, the magnesia increasing the fusibility of the slag if not in greater proportion to the lime than the proportions 2CaO.MgO. The amount of flux added is variable, it depends on how basic the slag must be made.

If the fuel is coke, and therefore considerable sulphur comes into the furnace, the slag formed must be nearly half lime and magnesia, to make low sulphur pig iron; if the fuel is charcoal, carrying almost no sulphur, and if the ores carry none, the slag may be only one-third lime and magnesia and two-thirds silica and alumina, and still make best quality pig iron. Such slag costs less for flux and is more fusible than the basic lime slags.

Fuel is needed to provide heat and reducing effect. The heating effect is almost entirely produced by the combustion of the larger part of the fixed carbon (non-volatile carbon) of the fuel to carbon monoxide (CO) before the tuyères. This combustion fills two functions: It provides the high temperature necessary to melt down the iron and slag, and it provides large quantities of reducing gas, practically identical in composition with producer gas (30 to 35% CO, 1 to 2% H_2, rest N_2), which does in the upper part of the furnace the larger part of the reduction performed in the furnace.

The amount of fuel used in a blast furnace is determined by the amount which must be burned at the tuyères to produce the necessary smelting temperature, and not by the amount necessary to perform the reduction of the metallic oxides. The amount necessary for performing the reductions taking place in the furnace is only one-third to one-half of the amount necessary to be burned to provide the smelting heat.

That this statement is true of the ordinary blast furnace may be seen from the fact that if the smelting zone is increased in temperature by heating the blast, the amount of carbon used in the furnace per unit of pig iron made is at once decreased. Or, if the heat available in the smelting zone is increased by drying the blast, and thus removing the strong cooling influences which the decomposition of the moisture of the blast exerts, economy of fuel at once results. In fact, any means of getting high smelting temperature without combustion of carbon before the tuyères, decreases at once the quantity of fuel necessary to use in the furnace, since the quantity used is determined by the heat requirements in the smelting zone and not by the requirements for reduction, which are only a fraction of the former.

The ash of the fuel is largely silica, with some alumina and lime, if coke, or alkalies, if it is charcoal. This requires, to slag it, an amount of flux which may be considerable when using poor coke high in ash. Regard for this item of cost should be had in purchasing or valuing the fuel.

The pig iron produced contains carbon between 2.5 and 4.5%, silicon in varying quantity, 1 to 4%, according to the temperature and rate of running of the furnace, practically all the phosphorus of the charge, and one-tenth to one-fourth of the sulphur. Its melting point is about 1,200° C., and it runs from the furnace ordinarily at 1,500° to 1,600° C., carrying out as sensible heat 250 to 300 calories.

The slag may be basic or acid, as before explained, and these varieties will average in per cents. as follows:

	Basic slag, high sulphur charge.	Acid slag, low sulphur charge.
SiO_2	35	55
Al_2O_3	10	10
CaO	40	25
MgO	10	5

These slags melt at about 1,350° and 1,200°C., respectively, and ordinarily run away from the furnace at 1,600° C., carrying out as sensible heat 500 calories.

The reduction of silica and phosphorus oxide in the furnace is accomplished by solid carbon in the smelting zone. A small part (10 to 20%) of the iron oxide in the furnace is also similarly reduced by fixed carbon; the rest is reduced in the upper half of the furnace by the excess of carbon monoxide gas. So much of the latter gas, however, is produced before the tuyères in generating the temperature necessary in the smelting zone that only a fraction of it is converted into carbon dioxide, CO_2, in reducing the iron oxides of the charge. This is the chief reason for the excess of unused carbon monoxide in the gases of the blast furnace, whose potential calorific value often represents one-half of the calorific power of the fuel put into the furnace.

It is true that all the carbon monoxide in the gases could not be utilized no matter how small its amount, but there is a limit set by the principle of chemical equilibrium or mass action, which ordinarily is not approached because of the excessive amount of carbon monoxide produced in the lower part of the furnace in the effort to get the requisite smelting heat and temperature. The proportions of carbon ordinarily consumed at the tuyères are 9 atoms (108 parts) of carbon for each molecule of iron oxide (160 parts) reduced by the carbon monoxide gas. The chemical equation is:

$$Fe_2O_3 + 9CO = 2Fe + 3CO_2 + 6CO.$$

This equation shows us that only one-third of the carbon monoxide produced before the tuyères, in generating the smelting temperature, is utilized in reduction, while two-thirds escapes unused.

Electric Smelting Furnace.

Passing to the electric principle of smelting, we have here to deal with the case of all necessary heat supplied by electrical energy, no blast blown in and therefore all the solid carbon utilized for reduction (always excepting the small amount which dissolves in the pig iron).

In calculating the amount of carbon necessary to thus reduce the iron oxide, we meet at the outset with this problem: What proportion of the carbon will form CO_2 and what proportion CO? We know that when reduction takes place at a very high temperature, CO is almost the only product; but as this passes more or less slowly through the cooler portions of unreduced charge, CO_2 is formed in increasing amounts, until at a low red heat, given sufficient time, about half the CO may be converted into CO_2. The formulas corresponding to these two extremes are:

$$Fe_2O_3 + 3C = Fe_2 + 3CO.$$
$$Fe_2O_3 + 2C = Fe_2 + CO + CO_2.$$

Comparing these with the ordinary blast furnace reaction, which requires 9C put into the furnace for the reduction of Fe_2O_3, we see that 3C, or one-third as much carbon, is the greatest amount necessary in the electric furnace reduction, and 2C, or between one-third and one-fifth as much, is the smallest amount necessary. As will be further shown, the uncertainty as to how much CO_2 can be formed in the electric furnace reduction is perhaps the chief difficulty in running the electric furnace.

EXAMPLE.—Iron ore is to be reduced to pig iron in an electric furnace, and the flux and charcoal on hand for the charge analyze as follows:

Iron Ore.		Limestone.		Charcoal.	
Fe_2O_3	90	$CaCO_3$	90	Fixed C.	90
SiO_2	 8	$MgCO_3$	 8	Volatile Mt'r..	6
Al_2O_3	 2	SiO_2	 2	SiO_2	 2
				Al_2O_3	 1
				K_2O, Na_2O	 1

Assume the pig iron made will contain 4% of carbon and 3% of silicon; that the slag may be 65% SiO_2 plus Al_2O_3; that the gases contain only the CO_2 from the limestone, and none from the reductions.

Required: (1) The parts by weight of ore, limestone and charcoal to charge per 100 parts of pig iron made. (2) The percentage composition of the gases. (3) The weight and percentage composition of the slag.

Solution: (1) The weight of ore needed is that necessary to supply 93 parts (100–4–3) of iron in the pig iron.

This will require $93 \times \frac{160}{112} = 133$ parts of Fe_2O_3, which will be contained in $133 \div 0.90 = 148$ parts of ore.

The weight of charcoal needed is that necessary to

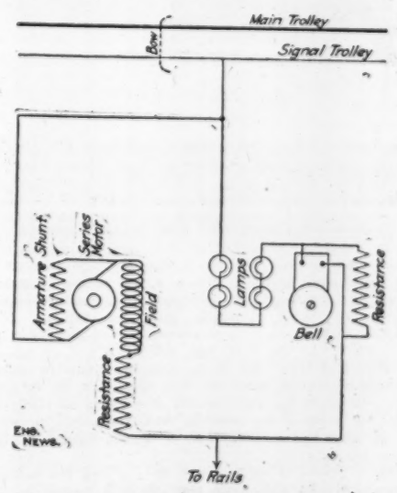


Fig. 3. Electrical Connections; Swiss Automatic Grade-Crossing Gate.

furnish enough fixed carbon to reduce the iron oxide and that silica which is reduced, and to supply the carbon in the pig iron. These quantities are:

Reduction of Fe_2O_3: $93 \times \frac{36}{112}$	= 29.9
Reduction of SiO_2: $3 \times \frac{24}{28}$	= 2.6
For carbon dissolved	= 4.0
Total requirement	= 36.5
Charcoal required $\frac{36.5}{0.90}$	= 40.6

*A paper presented at the meeting of the American Electrochemical Society, at Niagara Falls, Can., May 6-8, 1909.

†Lehigh University, South Bethlehem, Pa.

The weight of flux required is best found by calling it x, and then figuring out the slag, as follows:

Silica in the slag will be that in the ore, flux and fuel, minus that reduced to silicon. Therefore,

In ore	148	× 0.08	= 11.8
In flux	x	× 0.02	= 0.02 x
In fuel	40.6	× 0.02	= 0.8
Reduced	3	× 60/28	= 6.4
Silica in slag			= 6.2 + 0.02 x

By similar calculations we find the slag to contain, as a whole,

Silica	6.2 + 0.02 x
Alumina	3.4
Lime	0.50 x
Magnesia	0.04 x
Alkalies	0.4
Total weight	10.0 + 0.56 x

If 65% of the slag is to be silica and alumina together, then

$$0.65\ (10.0 + 0.56x) = 9.6 + 0.02x$$

from which $x = 9$.

The above solution is perfectly general, and applies to all kinds of ore, flux and fuel, and the production of any desired kind of slag.

(2) The gases will contain the fixed carbon of the charcoal (except that part which goes into the pig iron) in the state of CO, the carbonic acid driven off the flux, and the volatile matter from the charcoal. The latter may be assumed as composed of equal parts by volume of hydrogen, carbon monoxide, and carbon dioxide, which would correspond to weights of those gases in the proportion of 2:28:44. The gases passing off will therefore be, in parts by weight,

CO from fixed carbon	32.5 × 28/12	= 75.8		
CO from volatile matter	2.7 × 28/74	= 1.0	76.8	
CO_2 from volatile matter	2.7 × 44/74	= 1.6		
CO_2 from flux	9.0 × 0.44	= 4.0	5.6	
H_2 from volatile matter	2.7 × 2/74	= 0.1	0.1	
Total weight of gases				82.5

Percentage composition of gases by volume,

CO	76.8 ÷ 1.26	= 61.0	=	92.4%
CO_2	5.6 ÷ 1.98	= 2.8	=	4.2%
H_2	0.1 ÷ 0.00	= 2.2*	=	3.4%
		66.0		100.0%

The volumes 61.0, 2.8 and 2.2 represent cubic meters of these gases per 100 kilograms of pig iron made; if multiplied by 16 they give the cubic feet per 100 lbs. of pig iron.

(3) The slag will contain, substituting x = 9:

Silica	6.4 =	42.4 %
Alumina	3.4 =	22.5 %
Lime	4.5 =	29.8 %
Magnesia	0.4 =	2.65%
Alkalies	0.4 =	2.65%
	15.1	100.00%

CHARGE SHEET—Per 100 of Pig Iron Produced.

Charges		Pig Iron		Slag		Gases	
Ore:	(148.0)						
Fe_2O_3	133.2	Fe	93.0			O	40.2
SiO_2	11.8	Si	3.0	SiO_2	5.4	O	3.4
Al_2O_3	3.0			Al_2O_3	3.0		
Limestone (9.0)							
CaO	4.5			CaO	4.5		
MgO	0.4			MgO	0.4		
SiO_2	0.2			SiO_2	0.2		
CO_2	4.0					CO_2	4.0
Charcoal: (40.6)							
Fx'd C	36.5	C	4.0			C	32.5
CO	1.0					CO	1.0
CO_2	1.6					CO_2	1.6
H_2	0.1					H_2	0.1
SiO_2	0.8			SiO_2	0.8		
Al_2O_3	0.4			Al_2O_3	0.4		
$(NaK)_2O$	0.4			(NaK) $_2O$	0.4		
Totals	197.9		100.0		15.1		82.8

Combined Blast and Electrical Furnace.

The electrical reduction of iron ore differs radically from blast furnace practice in one essential particular, viz., that since no air is blown in, any excess of carbon above that consumed in reduction must remain unused, accumulate and eventually clog the furnace. The amount to be used as a minimum cannot, moreover, be calculated until we know how much CO_2 will be formed in reduction, and that is an unknown quantity unless arrangements are made so that none can be formed. The four following modifications of working an electrical pig iron furnace are possible, with the object in view of avoiding the accumulation of excess carbon in the crucible.

(1) A deficit of carbon may be put into the charge, thus permitting unreduced iron oxide to escape in the slag, and preventing unused carbon from accumulating. This solution leads to the disadvantages of loss of iron, heavy corrosion of lining of furnace and heavy consumption of electrode carbon. It may have the secondary result of preventing reduction of silica or taking up of carbon by the iron, and may thus furnish a metal with high melting point and approaching steel in composition. Such slag would also remove some of the phosphorus in the charge, but practically no sulphur.

*We have not attempted to correct several apparent minor errors which do not materially impair the illustrative value of the example.—Ed.

(2) A charge of ore and flux without fuel may be run through the furnace whenever an accumulation of carbon occurs, as is shown by the resistance of the furnace falling off and the furnace getting cold. This was the device adopted in the experiments of the Canadian commission at Sault Ste. Marie, but while permissible in experimental work, it would not do to thus periodically derange a furnace in regular running.

(3) The fuel may be calculated only for the production of CO in the furnace, and this condition is approximated by leading off the gases from the hot part of the furnace and not allowing them to cool in contact with the ore. In this way, reduction by CO is avoided, and the fixed carbon in the charge may be consumed almost entirely to CO without formation of CO_2. This would bring the furnace consumption of carbon nearer to a definite amount and, by avoiding reduction except by solid carbon, would tend to use up all the carbon charged, the amount of which would be calculated for this manner of working (as in the numerical example worked out for illustration).

(4) The best solution of this difficulty may be to provide tuyères by which air can be sent into the crucible of the furnace, and thus burn any accumulation of carbon. A given quantity of air will always burn a given quantity of carbon, and therefore the cure would seem to lie in having a variable supply of air, which is increased whenever the falling resistance of the furnace indicates that carbon is beginning to accumulate, and diminished to a small minimum supply, only enough to keep the tuyères open, when the furnace is in good electrical running order. It would represent a combined electrical and blast furnace, with the blast so regulated as to overcome the chief difficulty of the purely electrical furnace—the accumulation of unused carbon in the crucible.

It may be quite possible, by some such device as Mr. Taylor's large electrical furnace, to practically combine the blast furnace and the electrical furnace. The writer is quite confident that any practicable method of introducing electrical heat into the crucible of a blast furnace will result in large economies in the furnace working. Only one-quarter of the heating power of the fuel is developed around the blast tuyères, and yet if half of this could be replaced by electrically generated heat, an economy of 50% could in all probability be reached upon the fuel bill.

To put it into figures, it takes 1.2 tons of coke to make a ton of pig iron in the blast furnace, and about three-quarters of a ton is burnt by the blast, producing at the smelting zone about 25% of the calorific power of the coke. If electrical energy could be made to supply only one-half of this, the furnace would make iron with half the previous coke supply, that is, with 0.6 ton of coke per ton of pig iron, and this with an expenditure of electrical energy equal only to 12.5% of the calorific power of the coke, that is, equal to the calorific power of but 0.15 tons of coke.

The question of economy in this case will not be, then, the simple replacement of fuel heat energy by an equivalent amount of electrical heat energy, but the comparison of fuel heat energy with the cost of one-fourth its amount of electrical heat energy. This may be quite possible in many localities, and the combined furnace would work more regularly than a purely electrical furnace. The question awaits the coming of the electrometallurgical engineer who can make practicable the requisite combination. A possible solution may be to use cheap electrical power to super-heat the hot blast, and thus to make the blast itself the agent for carrying electrically developed heat into the furnace.

Notes from Engineering Schools.

UNIVERSITY OF WISCONSIN.—A six-weeks' course in public-utilities service testing and accounting has been arranged for the summer session opening June 28 and closing Aug. 6.

The testing course consists largely of experimental work in the electrical and chemical laboratories. In the former there will be meter tests and standardization tests on incandescent and other lamps to determine power consumption and photometric efficiency, etc., etc. In the other laboratory the work will comprise meter proving and the standardization of meter provers, testing for the heating values of coals and gases, determination of sulphur and other contents in gases and coals, etc. There will be some work in the hydraulic laboratory on the testing of water meters, measuring the height and discharge of fire streams, slip of pumps, etc.

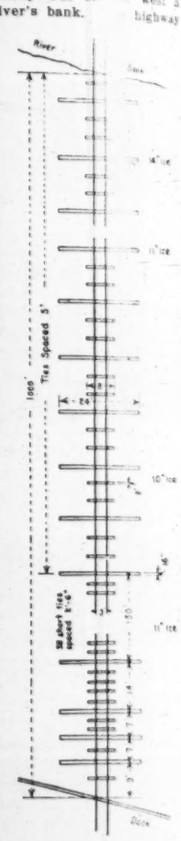
The course in accounting will provide instruction to show the basis on which the Railroad Commission of Wisconsin has prescribed the various uniform classification of accounts to be kept by all public service concerns.

The fee for students taking any or all of the courses named above will be the regular summer session amount, $15.

Hauling a Contractor's Plant Across the Ice on the Hudson River.

The strength of ice on a large body of water is not a matter of any exact knowledge or record, so the following account, taken from the Barge Canal Bulletin, April, 1909, of the transportation across the ice of the larger part of a contractor's plant on the New York State Barge Canal, has a unique interest.

Lock No. 4 of the Champlain Canal is to be built on the west side of the Hudson River, opposite the village of Stillwater. The nearest railroad station is to the east at Schaghticoke—six miles away—but on the west a trolley line is close to the river's bank. highway bridge at this point is an old structure and also too light for heavy loads.



STILLWATER
Plan of Track Laid Across Ice on Hudson River Used in Transferring Contractor's Plant.

To avoid the necessity of hauling their plant overland for six miles, the contractors conceived the idea of delivering the machinery by trolley on the west bank and taking it across on the ice. The heaviest single piece was a steam-shovel, weighing about 70 tons when in working order. This could be stripped to about 45 tons by removing the boom and dipper, which weighed some 15 and 10 tons, respectively. There were also three locomotives, weighing 18 tons each, which could be stripped to 15 tons. In addition the plant contained the usual hoisting engines, dump-cars, drills, etc., some pieces weighing as much as 12 tons. This machinery was delivered at Stillwater on Jan. 12, 1909.

In this vicinity the river freezes ordinarily to a depth of about 18 ins., but during the present mild winter it has been only about half that amount. To increase the thickness of the ice, the contractors devised the plan of cutting holes and flooding the surface by pumping water upon it. By this means a thickness of from 10 to 14 ins. was obtained. The contractors waited for about a month, but then, as it seemed too late in the season to expect any protracted cold spell, it was determined to begin operations. Moreover, on Feb. 4 there was a threatened thaw, and lest they should lose all for which they had been waiting, they decided to proceed with all possible speed. Accordingly they placed their tracks in position, working all night, so as to be ready for transporting the machinery on the next day.

Meantime, on the afternoon of the fourth, a trial load weighing about 15 tons had been run out upon the river. The ice seemed to bear this weight safely and the contractors felt confident of success in transporting at least the greater part of their plant. It was especially desired, of course, to get the steam-shovel across and to put it at work excavating, and the long and expensive labor of carrying this machine overland had furnished the chief reason for waiting for the formation of this ice bridge, but it had been decided from the first to test the ice with the locomotives before risking the heavier and more costly shovel.

For spreading the weight over a wider area, 8 × 16-in. yellow pine timbers, 24 ft. long (see accompanying figure) were placed beneath the narrow-gage railway. The river at this point is 1,000 ft. wide and these long timbers were used for about four-fifths of the distance across from the east bank, being spaced 15 ft. apart. In each space two 8-in. ties, 8 ft. long, were placed, thus making distances of 5 ft. between the supports for the track. The plant was to reach the ice from a dock on the west bank. To sustain the shock of this abrupt descent, the ties and long timbers were spaced much closer at this place, as will be seen in the accompanying sketch. The supply of 24-ft. timbers was not sufficient for the whole distance, and, so, near the west bank, there was a stretch of 150 ft. in which the track was supported by the 8-ft. ties alone, but spaced 2½ ft. apart.

Early on the morning of the fifth the contractors began

pulling over their machinery, the lighter loads being taken first. A hoisting engine had previously been hauled across and this was placed on the east bank. A cable 1,600 ft. long stretching from this engine to the opposite bank was used to pull over the desired loads. By taking several turns with this cable around a spool on the drum shaft the various machines could be transported while the men were on shore, and it was not necessary to risk the life of someone upon the ice when the heavy loads were being carried. Moreover, when once started these burdens could thus be quickly hauled across.

The greatest strain came in the afternoon, when the three locomotives were being carried over. To obtain data on the supporting power of ice, the engineers in charge of this contract had taken a series of levels upon the track. Then by fastening a leveling rod to a locomotive the fluctuations of the ice surface could be determined while the load was in transit. It was thus learned that the ice did not sink quite so much as appeared to the eye, for the surface seemed to take a great billowy motion as the locomotive advanced. The levels showed that the ice sank under the weight about 4 ins., on the average, a maximum of some 6 or 7 ins. being reached. It took about four minutes to haul over a single locomotive. The wave-like undulation of the ice beneath it may be likened to the conditions which exist when a skater goes rapidly over a thin surface. There was also a shattering of the ice and numerous cracks were opened.

While transporting one of the locomotives, the hoisting engine stalled for a short time, just as the machine was upon that portion of the track where there were no long timbers. The ice sank to a considerable extent and the water began to appear on the surface; it seemed for a moment that the locomotive would be lost, but danger was averted, and it was safely taken across.

After the locomotives were taken over, the boom and the dipper of the steam-shovel were transported separately and the work continued until 2 o'clock the next morning before all the machinery except the steam-shovel was moved. This did not get so far as the ice. After bringing it close to the river, it was finally decided that it was not safe to make the attempt. Then, after waiting for several days, during which there was no indication that the ice would become stronger, it was determined to move the shovel by the overland route, and it was accordingly taken to Schaghticoke and carried over the highways for six miles, a task that involved about a week's labor. Fortunately for the contractors, while the shovel was being moved, there was almost no snow upon the ground, but a thin layer of ice covered the surface. It was thus possible to haul the rails easily and to lay the track without ties, a few flat iron rods holding the rails together and in position. The machine was moved for about $100 a mile.

Although it is not possible to say that the ultimate load for ice under the existing conditions was reached, yet it would seem that the tonnage taken was near to that limit. The ice in the vicinity of the track was badly shattered and fissured, somewhat as a piece of thin ice or a pane of glass would be from a severe blow. The cracks in general did not extend many feet beyond the timbers and ties, but in some instances they reached to a distance of some 40 ft. away. The ice may be described as simply of ordinary quality, probably not so strong as a clear, quickly-frozen ice, although the contractors had taken the precaution of keeping the snow removed from the site of the crossing, so that it was not what is known as snow ice. A thaw had been in progress during the day and probably the ice was weaker then on the preceding day when the test load was carried.

The engineer in charge of this residency, having witnessed these operations, states that, with ice in the condition it was at the time of the crossing, the maximum load of 15 tons appeared to be about all that 10 ins. would safely stand.

AN OVERCROWDED LAUNCH SANK in the Ohio River, four miles below Pittsburg, Pa., May 11, and 21 of the 30 men on board were drowned. The men were employees of the McKees rock plant, and as they had been working overtime none wanted to wait for a second trip of the gasoline launch which was to take them across the river. The boat was designed to carry not more than 20 passengers and, due to its overloaded condition, sank in midstream. Eight of the men were rescued by a skiff and one other succeeded in swimming to the shore.

A TORNADO IN KANSAS May 14 killed five persons and injured about 25 others in the vicinity of Hollis and Great Bend. Considerable property was damaged throughout the state.

A BOILER TUBE BURST May 15 on the steamer "James H. Hoyt," in Lake Erie, three miles off Fairport Harbor, Ohio. One man was killed outright and four others were reported as fatally injured. The boat is owned by the Provident Steamship Co., of Duluth, Minn., and operated by Pickands, Mather & Co. of Cleveland, Ohio.

DYNAMITE ON A SMALL BOAT exploded May 14 at Codjoes Key on the Key West extension of the Florida East Coast Ry. Three men were killed and twelve others injured. The vessel was known as quarter boat No. 3. Reports state that the explosion involved 700 lbs. of dynamite.

A BALCONY RAILING GAVE WAY in the new National Guard armory at Seattle, Wash., May 6, under the pressure of the excited crowd witnessing the finish of a ten-mile "Marathon" race. Sixty persons were very seriously injured in the fall which followed. The railing is described as flimsy iron piping and about 170 ft. of it was involved in the accident. Scores of spectators fell from the balcony upon the heads of those on the floor below. It is reported that the building was opened without having been inspected by the City Superintendent of Buildings.

A GERMAN EXPRESS TRAIN running from Basle to Cologne collided May 13 with a previously derailed freight train at Herlisheim, near Colmar. Four trainmen and one passenger were killed and twelve passengers were injured. The passenger train was destroyed by a fire which broke out in the wreckage. The derailment of the freight was due to the explosion of the boiler of its locomotive.

THE DERAILMENT OF A PASSENGER TRAIN on the Missouri, Kansas & Texas Ry. May 11 near Bonita, Tex., caused the death of three trainmen. The accident took place at a point where a freight train had recently been wrecked. In spite of orders to run slowly past this point the train was running at a high rate of speed when the derailment occurred.

A PASSENGER TRAIN on the Chicago & Alton R. R. was wrecked May 15 near Odessa, Mo. About 40 persons were injured, two of whom are expected to die. The entire train with the exception of the locomotive left the rails. The rear coach, in which most of the injuries were inflicted, broke its coupling and rolled down the embankment. Reports state that the cause of the accident has not been discovered.

A PREMATURE BLAST IN A STONE QUARRY May 12 near the village of South Bethlehem, N. Y., eleven miles southwest of Albany, caused the death of 29 men. Among those killed were John H. Callanan, Vice-President and General Manager of the Callanan Road Improvement Co., which operate the quarry, and his brother, Chas. D. Callanan. Reports state that 13 holes 5 ins. in diameter and 75 ft. deep had been drilled at points about 20 ft. back from the face of the rock. Six of the holes had been charged with 500 lbs. of dynamite each and the men were charging the seventh when the explosion occurred. It was found that five of the charges remained unexploded after the accident. All but one of the 29 bodies of the victims was reduced to small fragments.

BONDS FOR MUNICIPAL OWNERSHIP OF WATER-works at Omaha were voted at the recent city election. The amount authorized was $6,500,000. This would cover the appraisers' award of $6,283,795 made a few years ago for the property of the Omaha Water Co., devoted to supplying Omaha and South Omaha. The city considered the award excessive and the matter went into the courts. The city was defeated in the lower court, but we understand that the case is still pending in the U. S. Supreme Court. It is hoped locally that the controversy may soon be brought to an end, either by a decision of the litigation or by compromise. The question of acquiring the works has been up for more than ten years. In 1898 the State Legislature authorized the city to buy the works and to issue $3,000,000 of bonds to pay for them. Soon after these bonds were authorized by popular vote. Appraisers were not appointed, however, until 1903, and their award was not submitted until July, 1906. For a number of years past, the city has withheld payment of hydrant rental and the company has secured judgment for it in the courts every six months.

MUNICIPAL OWNERSHIP OF WATER-WORKS at Kansas City, Kans., has been authorized by a heavy popular vote (4,336 to 322). The vote was on the issuance of $1,097,630 of bonds to buy the plant of the Metropolitan Water Co. Bonds to the amount of $400,000 for the enlargement and improvement of the system to be bought were also voted. Although the vote in favor of the propositions named was almost unanimous, yet it is stated that only one-fourth of the total vote of the city was cast. It is stated that as soon as the bonds are sold, a water-works commission will be appointed by Mr. U. S. Guyer, Mayor of the city. The population of Kansas City, Kan., by the census of 1900 was 51,418.

THE ATLANTIC TRANSPORT LINER "MINNEwaska" reached New York on her maiden voyage May 10, 1909. This is the latest and the largest of the fleet of the company. She is 616 ft. in length, 66 ft. in breadth and 39 ft. in depth, and is driven by twin-screw, quadruple-expansion engines capable of developing 17 knots speed. Like all of the other vessels of the Atlantic Transport Line the "Minnewaska" carries only first-class passengers, but this first and only cabin is most commodiously and tastefully arranged for the 326 allowed passengers. The boat will travel between New York and London direct, and consequently is provided with extra large freight capacity.

CASUALTIES TO PASSENGERS on the Pennsylvania R. R. system during 1908 were very few. No passengers were killed and only 102 were injured as a result of train accidents, out of the 141,659,543 passengers carried during the calendar year.

IN THE KEY WEST EXTENSION of the Florida East Coast Ry., a steel superstructure, supported on concrete piers, is to be substituted instead of the reinforced-concrete arch construction used on the Long Key Viaduct of the same road. At Knights Key Viaduct and Moser Channel Viaduct, 6,800 ft. and 7,760 ft. in length, respectively, 80-ft. deck plate girders will be used. At Bahia Honda Viaduct, 4,500 ft. in length, 125-ft. riveted and 182-ft. pin-connected spans have been designed. According to official information from the engineers of the road, "the reasons leading to this change in form of construction were mainly the greater expedition that would be obtained in the completion of the work, and the changed condition of the steel market in comparison with that existing in 1905 when the plans for construction work were first made." This road, together with the long reinforced-concrete viaduct at Long Key., was described in Engineering News, Oct. 19, 1905, p. 407.

A TUNNELING RECORD of an average advance of 17½ ft. per day in limestone rock was made in April in the 16-ft. water tunnel being built under Lake Michigan from 73d st., at Chicago. From April 1 to May 1, with 27 working days, heading No. 2 was driven 468 ft. This heading is 4,200 ft. from the shore line, 133 ft. below datum (water level), with 30 ft. of water above the bed of the lake. From June 1, 1908, to May 1, 1909, with deductions for Sundays and holidays and 21 days loss of time, the daily average advance in this heading has been 14¾ ft. The contract for the Chicago tunnel is held by George W. Jackson, Incorporated.

INCREASED CLEARANCES BETWEEN STREET cars are to be obtained in Chicago, where hitherto the clearance between passing cars has been as low as 8½ ins. Several hundred cars are about to be built for the city railways and they have been designed 6 ins. narrower than the widest existing cars used on the city lines, under the direction of the Board of Engineers. This will increase the clearance to 14½ ins. In past years the insufficient clearance has been defended by street-railway men with the argument that, since it is dangerous in any event to stand between two passing cars, the practice will be discouraged by making the clearance so small as to make serious injury or death almost certain.

A NOVEL TYPE OF CONCRETE HOUSE CONSTRUCtion has recently been perfected by Mr. George M. Graham and applied to a residence at Glencoe, Ill. This building is described in May, 1909, Monthly Bulletin, No. 60, of the Universal Portland Cement Co. The columns and girders are of steel tubing, filled with concrete and the floors, walls and partitions of concrete laid on wires stretched between the framework members and acting as reinforcement. In erection, the tubular framework is first placed, then the wires which serve as forms on which to lay the concrete. Photographs and more detailed description are in the above named bulletin.

AUTOMOBILE SPEED METERS are being studied by the Swiss Department of the Interior. Makers of such devices have been invited to submit their apparatus by June 15 for testing. ("Schweizerische Bauzeitung.")

THE VALUE OF THE ROSIN PRODUCTION of the United States in 1908 surpassed that of the production of turpentine for the first time in the history of the industry. A circular issued by the Forest Service gives a comparison of values for the past four years as follows:

Year.	Turpentine.	Rosin.
1906	$14,960,235	$5,129,268
1905	15,170,499	8,725,619
1907	18,283,309	17,317,059
1908	14,112,377	17,783,500

The production of rosin in 1908 amounted to about 4,250,000 bbls. The decline in the value of turpentine in 1908 was due to a large extent to the drop in its market price in that year, while the prices for rosin were in closer conformity with those of 1907.

A LIFE-SAVING STEAMER for service in the North Pacific ocean has been put in commission by the U. S. government on account of the numerous wrecks in those waters. It is named the "Snohomish" and was built by the Pusey & Jones Co., of Wilmington, Del. The steamer is 152 ft. long, 29 ft. beam and 17 ft. deep, with a displacement of 800 tons on a draft of 12 ft. 4½ ins. The single screw is 11 ft. diameter, and is driven by a triple-expansion engine having cylinders 18, 29 and 47 ins. diameter and a stroke of 30 ins. Steam is supplied by a Scotch boiler for ordinary use, and a Babcock & Wilcox boiler in reserve, the water-tube type being adopted in order that steam may be raised quickly in emergency. The speed is about 12 knots. The equipment includes two 24-ft. steel lifeboats, life rafts, pumps for extinguishing fires and pumping out wrecked vessels, a Spencer-Miller cableway for operating a breeches-buoy, two powerful searchlights, wireless telegraph apparatus, and the Ardois system of lamps for night signaling.

A VALUATION OF THE RAILWAY AND CANAL property of New Jersey is to be made by a commission provided for by a joint resolution adopted by the Legislature of that state. The resolution first recites that no "new and complete inventory of railroad and canal property" has been made since 1886, and that it is desirable to have such an inventory for the "use of the people of the State, the Legislature, the State Board of Assessors and the State Board for the Equalization of Taxes." Accordingly, the Governor is authorized, subject to the approval of the Senate, to appoint three persons, at least two of whom shall be experts, to value all the railroad and canal property in the State, and submit an inventory of the same. Franchises are to be valued separately. The work will be done under the general direction of the Governor and on lines laid down by him. The work is to be completed and the report submitted to the Governor by Sept. 1, 1909, and the report must be made public and be submitted to the Legislature of 1910. The compensation of the commissioners, aside from reasonable expenses, is to be fixed by the Governor. Under the terms of this resolution, the Governor recently appointed Messrs. Samuel Whinery, M. Am. Soc. C. E., who resides at East Orange; Charles Hansel, M. Am. Soc. C. E., of Cranford, and Frank Stevens, of Jersey City.

MARCH RECORD OF TRACK SHIFTING MACHINES.—The seven track shifting machines in the Central Division [on the Panama Canal Work] moved a total of 713,133 ft. or 135 miles of track during March. In the Tabernilla District, track shifter No. 5 moved 227,095 ft., and No. 6 moved 140,463 ft., a total of 367,588 ft., or 69.6 miles, for the district. In the Bas Obispo District shifter No. 1 moved 71,017 ft., and shifter No. 7 moved 118,099 ft., a total of 189,116 ft., or 35.8 miles. In the Pedro Miguel District shifter No. 8 moved 69,429 ft.; shifter No. 2 moved 50,088 ft., and shifter No. 9 moved 36,222 ft., a total of 156,459 ft. or 29.6 miles.—"Canal Record," April 28.

MUNICIPAL HOUSING is to be undertaken at Rio de Janeiro, according to the following note from Consul-General George E. Anderson in a recent issue of "Daily Consular and Trade Reports":

The efforts made by the government of the federal district of Rio de Janeiro to provide sufficient acceptable housing for its working classes, which led the municipality itself to construct a number of tenement houses a year ago, have led to the letting of a contract by the ministry of public works, in behalf of the federal district, to Señor Mario Roche for the construction of the necessary supply of houses, the number provided for being a minimum of 800 houses and a maximum number of 4,000 houses, the exact number to be determined as the enterprise proceeds. Four types of houses are to be constructed. One is to accommodate three persons and to be rented for $7.50 gold per month; the second to accommodate five persons at $13.50; the third to accommodate seven persons at $18, and the fourth to accommodate ten persons at $24. The contractor will be allowed entrance free of all duty for all material covering 15 years, exemption from local taxes for the same period, the power of condemnation of private property for the sites of such houses, and similar privileges. The full complement of houses of the two smaller classes must be completed within two years.

Personals.

Mr. W. S. Cox, Master Mechanic of the Texas & New Orleans R. R., has been made Assistant Superintendent.

Mr A. L. Webster has been appointed City Engineer of Wheaton, Ill. He has also been elected County Surveyor for Du Page County.

Mr. Robert Brewster Stanton, M. Am. Soc. C. E., has removed his office in New York City from 66 Broadway to Room 557, Mutual Life Bldg., 32 Nassau St.

Mr. James B. Angell, whose resignation as President of the University of Michigan was noted in this column March 4, has been made President Emeritus.

Mr. Richard U. Sherman has become President of the Consolidated Water Co., of Utica, N. Y., succeeding Mr. E. LeB. Gardner, M. Am. Soc. C. E., resigned.

Mr. David J. Howell, M. Am. Soc. C. E., has removed his office in Washington, D. C., from the Huyler Bldg., 605 Twelfth St., to the Union Trust Bldg., 15th and H Sts., N. W.

Mr. F. L. Nicholson has been appointed Chief Engineer of the Norfolk & Southern Ry., in charge of construction and maintenance of ways and structures, with headquarters at Norfolk, Va.

Mr. W. A. Garrett, Chief Executive Officer of the Seaboard Air Line Ry., will resign, effective Nov. 1, to become Vice-President of the T. H. Simington Co., of Baltimore, Md., manufacturers of railway equipment.

Mr. Howard M. Ely has been appointed Superintendent of Water Works at Danville, Ill. He has for some time been Assistant Engineer for the Parker-Washington Co. on its contract for the Chicago water-works tunnels.

Mr. Leveratt S. Miller, General Manager of the Central New England Ry., has resigned that position to become President of the Millbrook Co. and allied companies, succeeding Mace Moulton, M. Am. Soc. C. E., deceased. Mr. Miller's headquarters will be in New York City.

Mr. Eugene L. Harman, M. Am. Soc. C. E., U. S. Assistant Engineer with the Mississippi River Commission for many years, has been placed in charge of the survey of the Tennessee River, under the direction of Maj. Wm. W. Harts, Corps of Engineers, U. S. A., at Nashville, Tenn.

Mr. R. A. Thompson, formerly Chief Engineer of the Texas Railroad Commission, has become Engineer for the Interstate Commerce Commission. The function of the commission's new department, of which Mr. Thompson is the head, will be the valuation of railways for the information of the commission.

Mr. E. M. Chandler has resigned as Engineer for the Tuolumne Water Power Co., of Sonora, Cal., to become Engineer and Manager for the Pasco Power & Water Co., with offices at Burbank, Walla Walla Co., Wash. In his new position, he will have charge of the design and construction of works for irrigating ultimately 100,000 acres.

A number of changes have been made among the superintendents of the Chicago, Burlington & Quincy R. R.: Mr. L. B. Allen, General Superintendent of the Wyoming district, has been transferred to the Iowa lines. Mr. E. P. Bracken, Division Superintendent at Galesburg, Ill., has been transferred to the Wyoming district. Mr. H. E. Byram, General Superintendent of the Nebraska district, has been transferred to the general offices in Chicago. Mr. S. H. Shultz, Division Superintendent at Brookfield, Mo., has been transferred to Galesburg, Ill. Mr. W. B. Throop, General Superintendent of the Iowa lines, has been transferred to the Nebraska district. Mr. W. C. Welsh, Assistant Superintendent at Brookfield, Mo., has been made Superintendent, succeeding Mr. Shultz.

Obituary.

Thomas A. Weston, of Stamford, Conn., died May 3 in New York City at the age of 78 years. He was the inventor of the differential pulley block, which has always been known by his name; the "Triplex" chain block and the Weston multiple-disk brake and friction clutch. The Weston blocks, which are made in this country by the Yale & Towne Mfg. Co., of Stamford, Conn., and in England by Tangye Bros., Ltd., of Birmingham, have come into world-wide use. Mr. Weston was born in England but came to this country at an early age and was for a time employed as a clerk in the old hardware house of Pratt & Co., in Buffalo, N. Y.

Engineering Societies.

COMING MEETINGS.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 25-27. Annual meeting at New York City. Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 1-4. Annual convention at Atlantic City, N. J. Secy., W. W. Freeman, 29 West 39th St., New York City.

AMERICAN WATER-WORKS ASSOCIATION.
June 8-12. Annual convention at Milwaukee, Wis. Secy., John M. Diven, 14 George St., Charleston, S. C.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 16-18. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 21-23. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
June 21-23. Annual meeting at Chicago, Ill. Secy., D. B. Sebastian, C. & E. I. R. R., 327 La Salle Station, Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 23-25. Annual meeting at Detroit, Mich. Secy., P. W. Drew, Wisconsin Central Ry., Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 24-25. Semi-annual meeting at New York City. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 28. Annual convention at Frontenac, N. Y. Secy., Ralph W. Pope, 33 West 39th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 29-July 3. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGI
July 6-9. Annual convention at Bret
Secy., Chas. W. Hunt, 220 West 57
City.

OHIO ELECTRIC LIGHT ASSOCIATIO
July 13-15. Annual convention at To
D. L. Gaskill, Greenville, Ohio.

AMERICAN SOCIETY OF HEATING
ING ENGINEERS.
July 15-16. Summer meeting at
Secy., W. M. Mackay, P. O. Box
City.

SOCIETY FOR THE PROMOTION OF
EDUCATION.
June 24-26. Annual convention in
Brooklyn. Secy., Arthur L. Wil
stitute, Brooklyn, N. Y.

CANADIAN SOCIETY OF CIVIL EN
meeting in Montreal, May 6, Mr. John C
Soc. C. E., delivered an address on "S
the Design and the Construction of the
pension Bridge."

CENTRAL RAILWAY CLUB.—At the
falo, N. Y., May 14, Mr. Frank Tuma,
Mechanic of the Erie R. R., presente
"Practical Instructions on Bituminous Fu

ENGINEERS' SOCIETY OF MILWAU
regular meeting of May 12, Mr. S. A. Gr
Soc. C. E., presented an illustrated paper
on Refuse Disposal with Special Referen
Milwaukee Plant."

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—At the annual meeting in New York City, May 18, Mr. Frederick P. Fish read a paper entitled "The Patent System in Its Relation to Industrial Development." Officers were elected as follows: President, L. B. Stillwell; Vice-Presidents, J. J. Carty, Paul M. Lincoln and Paul Spencer; Managers, A. W. Berresford, W. S. Murray, H. H. Norris, S. D. Sprong; Treasurer, George A. Hamilton; Secretary, Ralph W. Pope.

BOSTON SOCIETY OF CIVIL ENGINEERS.—At the meeting held in Lorimer Hall, Boston, May 5, Mr. F. P. Stearns and Mr. Allen Hazen spoke upon two different phases of the Panama Canal subject. Mr. John R. Freeman, who, in common with Mr. Hazen and Mr. Stearns, was a member of the board of engineers that accompanied President Taft on his inspection of the canal, had also been expected to address the meeting but was prevented by ill health from being present.

Mr. Stearns compared the lock canal now in process of construction and the sea-level project.

Mr. Hazen exhibited lantern slides showing the work of canal construction.

ENGINEERS' SOCIETY OF PENNSYLVANIA.—At a recent meeting of the Engineers' Club of Central Pennsylvania at Harrisburg, a reorganization was effected under the name which heads this item. The first annual convention of the new society will be held June 9-11 in Harrisburg, Pa., and one of the features will be an exhibition of devices of general interest to engineers. At the convention, a fund will be started for the erection of a building to serve as the headquarters of the society. The membership is given as nearly 1,000. The officers are: F. Herbert Snow, President; F. B. Mussen, First Vice-President; John P. Jackson, Second Vice-President, and E. R. Dasher, Secretary.

NATIONAL FIRE PROTECTION ASSOCIATION.—Among the papers to be presented at the 13th annual meeting, in New York City, May 25-7, are the following: May 25, "Automatic Sprinklers," "Fire Protection Coverings for Window and Door Openings," "Pumps," "Private Fire Supplies from Public Mains."

May 26, "Artificial Refrigeration," "The New York High Pressure System."

May 27, "Fire Proof Construction," "Concrete and Reinforced Concrete for Building Construction, "Concrete Building Construction," "Theater Construction and Equipment," "Signalling Systems," "Pneumatic Conveyors of Stock and Refuse." All these papers are committee reports.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—The 17th annual convention will be held at Columbia University and Pratt Institute, in New York and Brooklyn, June 24-26. The time and place for the convention have been chosen with the idea of making it a convenient place of meeting for all who wish to attend the convention of the American Institute of Electrical Engineers, the American Society for Testing Materials or the American Society of Civil Engineers.

In addition to contributed articles, there will be presented the "Report of the Joint Committee of Engineering Societies on Engineering Education," by Dugald C. Jackson; "Report of the Committee on Technical Books for Libraries," by Arthur H. Ford; "Report of the Committee on Engineering Degrees," by Wm. F. M. Goss; "Report of the Committee on Entrance Requirements," by Robert Fletcher. A special session will be devoted to the discussion of engineering mathematics by the committee of 15 appointed at the Chicago meeting of the American Association for the Advancement of Science. This committee has been asked to prepare a special report for the 1909 meeting of the Society for the Promotion of Engineering Education.